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QUARTERLY PROGRESS REPORT

DIVISION 6 — DIGITAL COMPUTER (U)

15 DECEMBER 1956

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The research reported in this document was supported jointly by the Department of the Army, the Department of the Navy, and the Department of the Air Force under Air Force Contract No. AF 19(122)-458.

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DIVISION 6 – DIGITAL COMPUTER

15 DECEMBER 1956

(Issued 16 JULY 1957)

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LINCOLN LABORATORY LEXINGTON, MASSACHUSETTS

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DIVISION 6 SUMMARY

Division 6, during September, October, and November, scheduled the first Experimental SAGE Subsector (ESS) shakedown tests for 3 December 1956; continued ESS subsystem tests using the XD-1 and WWI computers and Bath and South Truro radars; established the first Lincoln field test team which was on site at McGuire Air Force Base by mid-November; had adapted to ESS and had ready for release on 3 December the first package of the DCA program (the computer program for the active computer of a SAGE direction center); had installed and initially tested all 38 planes of the 256^2 (2.5 million bits) memory for the TX-0 and TX-2 computers; and concentrated the efforts of Group 61 on the problem of integration of new weapons with SAGE.

ESS shakedown tests for the first few weeks have been specified and will check out the simulation facility of the system, examine manual initiation and automatic tracking functions, and introduce operating personnel to the system. The first shakedown test will be made on 3 December 1956.

Seven error-rate tests on height-finders and five tests on radar-inputs subsystems were conducted during the quarter. Five of the height-finder and two of the radar-inputs tests provided good data for analysis.

The first test team was on site at McGuire Air Force Base by mid-November and by the end of the quarter, the utility system was installed and some subprograms of the DCA program had been checked out on the duplexed AN/FSQ-7 there. The RAND Corporation has hired some 30 people per month since September and these people began a 12-week training course on the operations of the DCA program to prepare them for the program installation they will carry on at sites throughout the SAGE System.

The DCA program was further divided into four "packages" of subprograms contributing to the functional build-up of the whole program. By the end of the quarter, the first of these packages, Package A, was completely coded, parameter checked, assembly tested, adapted and ready for operation in the first ESS shakedown test and for installation at McGuire. In addition, 14,000 registers of drum storage have been saved as a result of improvements to and simplification of the DCA program, thereby decreasing parameter checkout requirements, reducing demands on XD-1 computer time, and easing the shortage of drum storage, while only slightly affecting the overall program production schedule.

The first twenty planes of the $256 \times 256 \times 38$ memory for the TX-0 and TX-2 computer systems were operating with TX-0 early in September. By the end of November, all 38 planes had been installed and initially tested. It is expected that the minimum time required between references (cycle time) for the complete memory will be 6.0 μsecs.

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The problem of data-link message standards for the time-division system was studied at the request of AFCRC and a recommendation was made that message format standardization be deferred until more knowledge of the century-series interceptors is obtained. A study of the manual inputs system resulted in a recommendation that certain classes of incoming teletype messages be prepared for the computer by feeding them directly through an IBM-047 automatic card punch. The initial DCA program appears to be capable of handling 100 tracks within a 15.9 second frame (cycle) time with the present 8192-register memory.

R.R. Everett
Division Head

N.H. Taylor
Associate Division Head

J.F. Jacobs
Assistant Division Head

S.H. Dodd
Assistant Division Head

15 December 1956

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TECHNICAL INFORMATION RELEASES

1 June 1956 – 30 November 1956

TIR	Release Date	Material Released
1-167	15 June 1956	6M-3884-1, Supplement 5, "Master Reference List, AN/FSQ-7 Specifications."
1-169	29 June 1956	"BTL Specification, Gap Filler Subsystem Test Specifications."
1-170	2 July 1956	"Subsystem Acceptance Test, BTL Specification, Height-Finder Subsystem Test Specification."
1-171	5 July 1956	"WE Documents, Internal Communications, CC, and External Communications."
1-172	17 July 1956	6M-4364-1, "SAGE System Tests."
1-173	3 Aug. 1956	6M-3147-5, "Master Reference List L/L Requirements for Direction Center Buildings."
1-174	13 Sept. 1956	Bell Telephone Laboratories Specification, "Long-Range Radar Subsystem Test Specification," G-256683, dated 8 August 1956.
1-177	28 Sept. 1956	6M-4719, "Computing Frame Time and Core Memory Capacity in the AN/FSQ-7," dated 28 September 1956.
1-178	2 Oct. 1956	6M-4106-1, "Specifications for the AN/FSQ-8 Combat Control Central."
1-179	10 Oct. 1956	Bell Telephone Laboratories Specification, "Crosstell Subsystem Test Specification, G-257310," dated 21 September 1956.
1-180	22 Oct. 1956	Bell Telephone Laboratories Specification, "Telephone Communications Subsystem Test Specification," G-257532.
1-181	30 Oct. 1956	6M-4389, "Additional Testing Efforts in the First Module, McGuire, Stewart, Syracuse," dated 6 July 1956.
1-182	31 Oct. 1956	2M-0561, "Results of Mark X System Study," dated 15 October 1956.
1-183	9 Nov. 1956	6M-3851-3, S1, "Master Reference List of Equipment Specifications for XD-1," dated 15 October 1956.
1-184	9 Nov. 1956	6M-4106-1, S1, "Specifications for the AN/FSQ-8 Combat Control Central," dated 1 October 1956.
1-185	9 Nov. 1956	6M-3884-2, S1, "Master Reference List AN/FSQ-7 Specifications," dated 10 October 1956.
1-186	13 Nov. 1956	6M-3980-3, "Listing of Master Operational and Mathematical Specifications for SAGE Direction Center," dated 22 October 1956.
1-187	15 Nov. 1956	Bell Telephone Laboratories Specification, "Teletype and Facsimile Communications Subsystem Test Specification," G-257402.
1-188	26 Nov. 1956	Bell Telephone Laboratories Specification, "G/A Voice Radio Subsystem Test Specification," G-257311, dated 1 November 1956.

TIR	Release Date	Material Released
1-189	27 Nov. 1956	2M-0604, "Proposal for Redesign of Height-Finder Message Console," dated 9 October 1956.
		2M-0604 Addenda 1 and 2, "Proposal for Redesign of Height-Finder Message Console: Data Word Changes," dated 22 October 1956.
		2M-0605, "Minutes, Meeting on SAGE Height-Finding Message Console," dated 15 October 1956.
		2M-0613, "Floor Space for Height-Finder Message Console," dated 30 October 1956.
1-190	30 Nov. 1956	Bell Telephone Laboratories Specification, "Ground-to-Air Data Link Specification," G-257915, dated 8 November 1956.

GLOSSARY

AA	antiaircraft
AAOC	AA operation Center
a-c	alternating current
AD	air defense
ADC	AD Command
ADES	AD Engineering Service
ADPE	auxiliary data-processing equipment
ADSOD	Air Defense Systems Operation Division
ADW	Air Defense Wing
AEW	Airborne Early Warning
AF	Air Force
AFB	AF Base
AFCRC	AF Cambridge Research Center
AFIRO	AF Installation Requirements Office
AFMTC	Air Force Missile Test Center
AGC	automatic-gain control
AGET	Advisory Group on Electron Tubes
AI	airborne interceptor
AMC	Air Materiel Command
AMIS	Air Movements Identification Service
APL	Applied Physics Laboratory
AQL	average quality level
ARAACOM	Army Antiaircraft Command
ARDC	Air Research and Development Command
ARTCC	Air Route Traffic Control Center
ASC	Air Situation Coordinator
ASESA	Armed Services Electro-Standards Agency
ASO	Air Surveillance Officer
ASR	automatic send-receive
AST	air surveillance
ASTM	American Society for Testing Materials
ATABE	Automatic Target-Battery Evaluation
ATC	Air Training Command
ATCF	ATC Facility
ATO	Air Tactics Officer
ATT	Air Tactics Technician
B-N	bariated-nickel
BOSCO	BOMARC-SAGE Compatibility
BTL	Bell Telephone Laboratories
BSO	Battle Simulation Officer
CAA	Civil Aeronautics Administration
CAT	category
CBS	Columbia Broadcasting System
CC	combat center
CCDC	Cape Cod Direction Center
CDC	call direction code
CCS	Cape Cod System
CER	change evaluation request
C&E	communications and electronics
CHT	Charactron tube
CM	core memory
Codan	Carrier-operated antinoise muting system
CP	Command Post
CPO	command pulse output
CRT	cathode ray tube
CS	coding specification(s)
DAB	display assignment bit
DACL	Dynamic Analysis and Control Laboratory
d-c	direct-current
DC	direction center
DCA program	the computer program for the active computer of a SAGE direction center
DCO	Design Control Office
DD	digital display
DDG	DD generator
DDL	Division of Defense Laboratories
DDR	digital-data receiver
DDT	digital-data transmitter
DGP	data-generation program
EADF	Eastern Air Defense Force
ECM	electronic counter-measure
ECP	engineering change procedure
EG&G	Edgerton, Germeshausen & Grier
EMAR	experimental memory address register
EPSCOM	Equipment Program Services Committee
ESS	Experimental SAGE Subsector
ERA	Electronic Research Associates
FF	flip-flop
FGD	fine-grain data
FM	frequency modulation
FORX	FGD orientation with Raydist and calibrated Mark X
G/A	ground-to-air
GFI	gap-filler input
GSR	group-selection register
HEC	Hazeltine Electronics Corp.
IBM	International Business Machines Corp.
ID	identification
IFF	identification – friend or foe
INS	interceptor simulator
IPS	initial program specification
IRE	Institute of Radio Engineers

GLOSSARY (Continued)

JETEC	Joint Electron Tube Engineering Council
KSR	keyboard send-receive
LPO	Lincoln Project Office
LRI	long-range radar input
LTPS	Lincoln tube process specification
MAR	memory address register
MC	marginal checking
MCD	marginal checking and distribution
MDI	manual-data input
MEL	minimum equipment list
M-G	motor-generator
MIL	Military
MISP	Manned Interceptor Simulation Program
MITE	multiple input terminal equipment
MOC	Mission Operations Center
MTC	Memory Test Computer
NAS	Naval Air Station
NET&T	New England Telephone and Telegraph Co.
n-p-n	negative-positive-negative
NRL	Naval Research Laboratory
OB	output buffer
OMR	operational modification(s) request
OPS	operations
OT	Overlap Technician
PCC	Planning Coordination Center
PCD	power control distribution
PCO	Production Coordination Office
PIUMP	plug-in unit mounting panel
p-n-p	positive-negative-positive
PPI	planned-position indicator
PRF	pulse repetition frequency
pps	pulses per second
PT	Plotting Technician
QPR	Quarterly Progress Report
RADC	Rome Air Development Center
RAFD	Rome Air Force Depot
RAND	Research and Development Corp.
RC	register containing
R-C	resistance-capacitance
RD	radar data
RECI	Request for Engineering Change and/or Information
RETMA	Radio, Electronics, Television Manufacturers Association
rf	radio frequency
ROTR	receive-only typing reperforator
S&EC	Scientific and Engineering Computation
SAC	Strategic Air Command
SAGE	Semiautomatic Ground Environment
SAHL	semiautomatic height-finder live
SAR	storage address register
SBT	surface-barrier transistor
SD	situation display
SDG	SD generator
SDV	slowed-down video
SIF	selective identification feature
SIZ	security identification zone
SC	Signal Corps
SCEL	SC Engineering Laboratory
SO	Systems Office
SOP	standing operating procedure
SOT	Systems Operations Test
STP	System Training Program
SPIS	SAGE Program Identification Service
TAPE	Technical Advisory Panel for Electronics
TBS	training and battle simulation
TCAP	Tactical Channel Assignment Panel
TD	track data
TIR	Technical Information Release
TRACALS	Traffic Approach Control and Landing Service
TT	Texas Tower
UHF	ultra-high frequency
VCM	vibrating-coil magnetometer
VHF	very-high frequency
WAD	weapons assignment display
WADC	Wright Air Development Center
WE	Western Electric Co.
WISE	Whirlwind I SAGE Evaluation
WL	warning light
wpm	words per minute
WSEG	Weapons System Evaluation Group
WSPO	Weapons System Project Office
WWI	Whirlwind I
XT	Crosstell, Crosstalk

SYSTEM DESIGN

GROUP 61

Israel, D. R., Leader

Anderson, H. E.
Boyd, H. W.
Earnest, L. D.
Fallows, R. S.
Garth, F. M.
Goldberg, S.
Goodman, H.
Hauser, S. J.
Hosier, W. A.
Jeffrey, L. R.
Ladd, D. W.
Litsios, S.
May, J. P.
Shay, J. W.
Sinesi, P. N.
Wolf, E. W.

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I. SYSTEM DESIGN
GROUP 61

A. SUMMARY

Group 61's responsibilities are now concentrated on the integration of new weapons with the SAGE System; responsibility for direction center operational and mathematical specifications was transferred to Group 67 early in the quarter. Employment meetings, sponsored by ADC, on the F101B and F106A manned interceptors were attended during September and October.

Questions regarding standards for ground-to-air data-link have developed and Lincoln Laboratory has suggested to the Lincoln Project Office that it would be inadvisable, at this time, to standardize on message formats and that the Air Force should establish a permanent committee for review of data-link problems.

Boeing Airplane Company conducted a 5-day course on the BOMARC weapon system at Lincoln Laboratory in November. Computation requirements for BOMARC guidance are being studied.

The frame (or cycle) time of the initial DCA computer program was studied on the basis of existing programs, and the following conclusions were drawn:

1. A frame time of no more than 15.9 seconds could be achieved for a 100-track capacity with the present (8192-register) core memory.
2. An increase to about 200 tracks within a 15-second frame could be achieved without a major program rewrite, but would require the use of the proposed 65,536-register memory.

Procedures and equipment of the Manual Inputs Room were studied during a series of tests, and several changes were recommended. A primary change will be the use of IBM 047 equipment for converting certain classes of incoming teletype messages to punched cards for insertion into the AN/FSQ-7.

D. R. Israel

B. GENERAL

1. Reassignment of Responsibilities

Group 61's responsibilities are now concentrated on the integration of new weapons systems with SAGE. In September, the responsibility for modifying or completing the direction center operational and mathematical specifications was transferred to Group 67. The WISE program was suspended, and Group 61's final activities regarding the direction center programs were the conduct of a series of tests of the manual-input function and the completion of a program-timing study.

2. Manual Inputs Test

A series of tests of various processing stages in the Manual Inputs Room was conducted to obtain data regarding the proposed procedures and equipment. The test plan, detailed experimental data, results, and recommendations were published in 6M-4534, "Tests of Manual Inputs System Design," 15 August 1956, and Supplement #1, 15 November 1956.

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Four basic systems of input were tested:

a. Telephone transmission of processed data from the message source to a clerk in the Manual Inputs Room who copied the message and passed the transcription to an IBM 026 card-punch operator who, in turn, punched the information into the card.

b. Telephone transmission of processed data from the message source directly to an IBM 026 card-punch operator.

c. Teletype transmission of the processed data which appeared on a printed tape in the Manual Inputs Room and was punched on a card by an IBM 026 card-punch operator.

d. Teletype transmission of data prepared at the source in a special form designed for use with an IBM 047 tape-to-card punch in the Manual Inputs Room.

The four basic systems were reduced for testing purposes to nine segments, each characterized by only one change of data form. The test inputs to the segments consisted of previously prepared and transcribed forms of four message types: flight plans, tracks, airbase weapons status, and airbase weather. Only one message type was used at a time to test the segments. Recorded measurements were used to determine an average error-rate and a rate of production of error-free cards for each system.

The recommended changes in processing of manual inputs as a result of these tests will yield the following processing system for the message types:

a. Track data from manual ADDC's and GOC's will be received on telephone directly by IBM 026 card-punch operators who punch IBM cards simultaneously with receipt of the messages.

b. Flight plans, track data from AEW aircraft and picket ships, airbase weather, weapon's status, and winds aloft will be received on teletype-punched tape and passed to an IBM 047 for automatic card-punching.

c. Other messages will be received by telephone, copied and passed to an IBM 026 operator for card-punching.

The adoption of these systems involves some changes in previous equipment requirements:

a. Elimination of the IBM 056 card verifier.

b. Introduction of two IBM tape-to-card punches.

c. Elimination of one IBM 026 card punch, leaving a total of four.

These changes, in which the 4620th Air Defense Wing (Experimental SAGE) concurs, are being processed for release by TIR.

3. Discontinuance of WISE

A review of immediate objectives has shown that the problem of testing and evaluating automatic crosstelling is overshadowed by projects of higher priority, and the Whirlwind I-SAGE Evaluation (WISE) programing effort has been suspended. Activity in this area over the past few months was limited to the assembly of subprograms in a single program package. A description of the programing effort will appear in 6M-4810, "Program and Coding Specifications for the Air-Surveillance Package of the WISE Program," which will describe the over-all program logic and coding of the individual subprograms and will serve as a guide or primary reference for operation of the air-surveillance package for anyone who undertakes to modify or add to the package.

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4. Direction Center Program Study

Ever since the DCA (Direction Center Active) program began to take shape early in 1956, there has been a need for information on the time required for a complete cycle or "frame" as defined by this program. Owing to the complexity of the SAGE System and the program itself, an experimental measurement of this time cannot be expected before the end of 1957; but important engineering decisions, such as the increase of core memory size, which demand a lead time of two years to get into the operational system, could not be so long deferred. For this reason, and in spite of obvious hazards and shortcomings of the method, some eighteen persons were recruited temporarily from Groups 61 and 64 during August and September to undertake a real-time study (on paper) of the SAGE DCA program. The objective of this effort was to obtain the best possible estimate, short of actually operating the program, of how long it might take to complete a frame cycle under various track loads.

The report of this study group has been issued as 6M-4754, "The SAGE DCA Program: Frame Time as a Function of Capacity," 22 October 1956. Due to a few minor internal inconsistencies and interim figures which were the result of the understandable pressure to get the report into print, it was issued as a working draft with limited distribution. Its conclusions are only as valid as its assumptions; the numbers stated should be regarded only as samples from a statistical distribution, subject to considerable variance.

The group's most significant conclusions are summarized as follows:

a. When revisions now being made to the DCA program by Group 67 and RAND are completed, the frame time for 100 tracks (omitting recording and simulation) is estimated at 15.9 seconds.

b. When the large 65,536-word core memory is installed at McGuire (probably late in 1958), the above program should handle about 200 tracks in a 15-second frame time, with no alterations other than re-grouping and re-addressing to take advantage of the larger memory. It will take from 24 to 34 seconds to handle 400 tracks, depending on the amount of radar data.

S. Hauser
W. Hosier
D. R. Israel

C. MANNED INTERCEPTORS

1. General Concept

During preparation of the SAGE/F-102A/MG-10 integration report with Hughes and Convair, and partly as a result of the recent series of weapon employment meetings held by Air Defense Command, it has become apparent that the integration of the century-series interceptors must be carried out as one integrated task and not as separate activities. Missile attacks, cruise control, formation tactics and snap-up are a few examples of problem areas common to many of the interceptors. Since a deep knowledge of each weapon system is necessary for the solution of integration problems, Lincoln Laboratory believes that the weapon contractors should take a leading role in these integration efforts.

Convair is the first interceptor manufacturer to accept and act on this idea, and is now planning to send between ten and twelve people to the Lexington area to work on F-102A problems with Lincoln Laboratory.

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2. The F-106A Employment Meeting

Lincoln participated in the F-106A employment meeting, which was called by ADC for 24 September at San Diego. Proceedings of the conference appear in the ADC report, "Employment of the F-106A Interceptor in the SAGE Era."

The F-106A fire-control system (MA-1) has a digital computer that is tied into the control surfaces and which automatically guides the interceptor to its target. Target position and velocity must be supplied from the ground through the data-link system. This kind of interceptor control is called "modified close control." Advantages claimed for it include:

a. Lessened susceptibility to data-link jamming.
b. Less computer and operator load on SAGE.
c. Greater guidance accuracy.

A major problem with this technique is the difficulty of conducting a coordinated air battle. ADC's meeting concerned itself largely with this problem, although specific conclusions were not reached.

The F-106A can also operate under the more conventional "close control" mode, in which case the MA-1 system flies the airplane in response to data-link commands. A great deal of operational flexibility was found to accrue from the use of the MA-1's digital computer.

3. The F-101B Employment Meeting

The last of the scheduled series of ADC manned-interceptor employment conferences was held for the F-101B interceptor during the week of 8 October at St. Louis. Results of the meeting are contained in the ADC report, "Employment of the F-101B Interceptor in the SAGE Era."

Most of the problems relating to the F-101B had already been encountered in earlier employment meetings. Its high speed (Mach 1.7), its Falcon missiles and MB-1 rockets, its snap-up capability and its long range (800 nautical miles) are all characteristics which had individually appeared and been discussed. The F-101B carries the MC-13 fire control system (similar to MG-10), manufactured by Hughes Aircraft Corporation.

4. Data Link

An Air Force (Hq., Det. #1, Wright-Patterson AFB) meeting was held at Lincoln in October for the discussion of frequency-division data-link problems in manned interceptors. Problems of simultaneous compatibility with SAGE, AN/GPA-37, TRACALS and BADGE were also considered. A general conclusion was that most of the desired changes could not be obtained in the era of frequency-division because of difficulties in making retrofits. It was expected that many improvements could be included when the time-division system is installed.

Lincoln has received a letter from AFCRC requesting our recommendations for data-link message standards for the time-division system. A reply was drafted in which it was pointed out that the present lack of knowledge concerning operational requirements for the century-series interceptors renders it inadvisable to standardize on a message format at this time. The letter further suggests that the Air Force establish a permanent data-link committee for the continuing review of data-link problems.

F. Garth
L. Jeffrey

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D. UNMANNED INTERCEPTORS

1. BOMARC

At the request of Group 61, Boeing Airplane Company agreed to conduct a course on the BOMARC weapon system at the Lincoln Laboratory during November. This course, attended by thirty Lincoln, IBM, RAND and Boeing people, covered:

a. airframe and hydraulics
b. electrical power
c. propulsion system
d. coordinate coverter system
e. control system
f. beacon system
g. ordnance.

The course was conducted to acquaint the people involved in its integration with the BOMARC weapon.

IBM has been preparing specifications for the XD-2 computer program to be used in research and development flights of the BOMARC weapon. When these specifications are completed, Lincoln will review them to establish if they are representative of the tactical SAGE computer program being planned.

A study of the probable SAGE computation time, necessary to solve the BOMARC guidance equations, has indicated that about 4 to 5 seconds will be required for 200 simultaneous flights. This time does not allow any in-out break time and does not take into account any other program changes requiring additional computation time. This study was conducted jointly by Lincoln Laboratory, IBM, RAND, and Boeing.

Plans for more joint Boeing-Lincoln activities are being prepared. These studies will be aimed at changes in the 1960 SAGE computer equipment and program that will result from the integration of BOMARC. Particular areas of concern are the use of missiles across subsector boundaries, computation frequency, and human-operator functions.

A brief study of an initial BOMARC capability has shown that between 20 and 50 simultaneous BOMARC interceptions per direction center are possible. This firing rate will probably be limited by available computation time, SIF interference, and initial missile availability.

H. Anderson

2. Talos

The SAGE-Talos integration committee met at Lincoln Laboratory, 9 to 11 October 1956, to continue its study of technical problems associated with implementing the ADC employment plan for Talos.* In addition, several informal meetings among committee members were held on various phases of the committee's report. The final report is expected to be issued during the next quarter.

One of the major technical problems studied was the transmission of data from a Talos detachment to SAGE. Data rates are low, but delays in transmission must not exceed several

*MIT Lincoln Laboratory Quarterly Progress Report, Section I., D., 6 (15 September 1956).

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seconds. Although the use of automatic teletype may be feasible, there are no low-data-rate input facilities in the AN/FSQ-7. This problem, coupled with other similar problems in handling low-data-rate inputs for other weapons, has led to a proposal for the establishment of a committee to review present and future input-output requirements. Lincoln hopes to start such a study in the near future.

J. May
E. Wolf

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ESS INSTALLATION

GROUP 62

O'Brien, J. A., Leader

Aronson, I.
Barrett, B. W.
Callahan, R. J.
Canty, W. J.
Carter, C. J.
Clarke, J. D.
Coffin, S. T.
Crane, J. D., Jr.
Durgin, F. R.
Gano, J. J.
Gerhardt, R. H.
Ginsburg, S. B.
Giordano, J.
Hingston, A.
Irish, F. E.
Jahn, R. C.
Malouin, J.
Paddock, R. B.
Sandy, G. F.
Sandy, T. J.
Werlin, A. M.

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A. SUMMARY

Error-rates observed during five out of seven height-finder subsystem equipment tests performed this quarter showed approximately 97 per cent agreement between the heights originally recorded at the computer and those received in replies from the AN/FST-2. These tests used the WWI computer and Bath or South Truro radars. The last two radar-inputs subsystem equipment tests resulted in successful printouts at both WWI and XD-1 from Bath and South Truro radars and from Ampex tape. One test checked 7480 pieces of data between XD-1 and the South Truro search radar with 96.1 per cent agreement and 2097 pieces of data between XD-1 and the South Truro Mark X radar with 100 per cent agreement.

The external wire communications that will be required for the first ESS shakedown tests were completely checked out and ready by the end of the quarter.

Marginal checking was resumed on the XD-1 computer and reliability was significantly improved in the central computer, drums, and core memory. Over-all reliability for the quarter was 85 per cent. The poor performance of the magnetic tape system is now being studied by a special group of IBM people who will also study other sources of computer troubles and devise ways of eliminating them.

J. A. O'Brien
W. J. Canty

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B. ESS SUBSYSTEMS

1. Radar Inputs and Height Finders

Twelve subsystem tests were conducted that provided data for analysis. Detailed results and analysis of the data obtained on these tests are published in 6M-notes under the title, "Radar Inputs Test Team Activities."

a. Height Finder

In error-rate tests, where the computer sends requests containing the "old" height to a height finder, and the height finder is not changed, the reply of "new" height should correspond exactly with the "old" height, barring jitter and errors in the FST-2 equipment. Error-rates observed during five out of seven such tests using WWI and Bath or South Truro radars during the quarter showed approximately 97 per cent agreement between old and new heights. The results of the test run on 9 October 1956 are representative:

The AN/FST-2 and both AN/FPS-6 radars at Bath were used. Agreement between height requests and height replies was 97.5 per cent. The goal is 99 per cent. Of 234 height comparisons made between old and new heights, two "no replies" were received from one radar and four from the other. Azimuth comparisons agreed 87 per cent within ±1° and 94.5 per cent within ±2°. The goal is 90 per cent at ±1°. Range comparisons were further out: distribution of recorded ranges at the site centered around +3 miles of the range sent, instead of the specified –2. Only 70 per cent were within ±1 mile of the center of distribution; 89 per cent were within ±2 miles. The specified value is 90 per cent within ±1 mile. A total of 214 ranges were recorded

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at the site compared with 315 azimuth readings taken. For the first time, operators recorded the following with the noted percentages of agreement between data sent and data received:

Task assignment and formation: 100 per cent

Separation: 99.6 per cent (one error in 271 comparisons)

Number of aircraft and special replies: 99.3 per cent (the goal is presently set at 90 per cent).

Error-rate comparisons were not as close in the other two tests. Difficulty experienced during the test of 23 October was attributed to the phone lines and resulted in 67.7 per cent agreement between height requests and height replies.

The test run on 19 November showed 88 per cent agreement between height requests and height replies. This relatively low percentage has been attributed to an inherent error in the WWI tracking program which selects azimuth angles in whole degrees and ranges to the closest half-mile, and converts them to x and y coordinates which are rounded off to the nearest half mile. This rounding off could give an error of as much as one degree at small ranges. It has been proposed that the program be changed to randomly select x and y coordinates to the nearest half-mile and eliminate the rounding-off error introduced by the original program.

On 25 October a test using XD-1 and the South Truro and Derry sites was run with a live B-29 aircraft which flew at 15,000 feet in an approximate circle, about 25 miles radius, with Derry as the center. Little search-radar data reached XD-1 over the Building F RAPPI from South Truro due to difficulty in the phone-line modulator at South Truro.

b. Radar Inputs

Five radar inputs subsystems tests were run, the last two of which yielded good data. Early test difficulties were attributed to the phone lines which, however, were found to be operating satisfactorily. The trouble was traced to printout errors in the tracking program. These errors were corrected and data was successfully printed out at both WWI and XD-1 from the Bath and South Truro radars and from Ampex tape. The last radar-inputs test of the quarter was conducted on 1 November with the following results:

Good agreement between data sent and data received with ±1/2 frame variation (i.e., corresponding search may be on different sides of corresponding Mark X). The RAPPI printout was in error about 10 per cent of the time and the RAPPI printer was thought to be at fault.

The test conducted on 8 October checked, using XD-1 and Ampex tape, 7480 pieces of data with the South Truro search radar with 96.1 per cent agreement and 2097 pieces of data with the South Truro Mark X radar with 100 per cent agreement.

2. External Wire Communications

The first group of external wire communications was checked out as scheduled and ready for ESS shakedown testing by the end of the quarter. No major problems were encountered.

3. Maintenance Studies

Several equipment-test programs were recorded on one magnetic tape for checking out the required console equipment prior to a mission or large-scale test.

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A program, needed to check keyboard push-buttons is being written.

4. Maintenance Coordination

The details of how the Maintenance Coordination Team will function during ESS operation were worked out. All troubles with ESS equipment that occur during tests will be reported to the Maintenance Coordinator, who will discuss them with the Test Engineer to determine their effect on the conduct of the test. The Maintenance Coordinator will then designate the member of the Maintenance Coordination Team who will take appropriate action (ref. 6M-4284, Supplement 4). A system is being prepared for recording and follow up on:

a. routine equipment troubles occurring during daily ESS operations
b. equipment or system deficiencies discovered as a result of prolonged ESS operations.

5. XD-1 Reliability

The AN/FSQ-7 (XD-1) computer performed with an average reliability of 85 per cent over this quarter; mean good time between failures was 2.24 hours. Marginal checking significantly improved the performance in some areas. The central computer, drums, and core memory operated at a high degree of reliability. During one month, 76 per cent of the incipient failures in the central computer were detected by marginal checking; 16 per cent were sudden failures and, therefore, not liable to detection by marginal checking.

With the improvement in general machine performance, the relatively poor operating record of the magnetic tape system became increasingly apparent. For many weeks half of the machine failures were attributable to the magnetic tape system. Toward the end of this period, the problem was attacked by IBM's System Maintenance Study Group, which has determined that most of the tape system failures are caused either by a buildup of oxide on the reading heads, or by "bad" spots on the tape. A strict routine of cleaning the reading heads, and of inspecting the magnetic tapes before use, has improved the machine performance. The problem, however, cannot yet be considered as solved.

I. Aronson C.J. Carter
F.E. Irish R.B. Paddock
T.J. Sandy A.M. Werlin

C. CIRCUIT SUPPORT

1. LRI Monitor Consoles

LRI monitor consoles equipped with cameras have been debugged and put into operation. All of the LRI consoles have had the improved deflection amplifiers and yokes installed and are now performing according to specifications.

2. Ampex Tape Unit

Tests to determine the feasibility of operating the Ampex tape at a tape speed of 15"/sec. instead of the present 30"/sec. have been started. These tape units are used to simulate either radar data entering a direction center or crosstell information leaving a direction center. A reduction in tape speed would result in less tape consumption and a reduction in reel size, thereby simplifying the tape transport problem, and would allow us to buy more nearly standard Ampex tape units, which are easier to obtain.

3. Centralized Probe System

The necessary duct work has been installed in Building F. All parts have been ordered and delivered. The cables have been cut to length and the ends finished, but must await a power shut-down of XD-1 before being installed.

4. Power

a. XD-1 D-C Supplies

General Electric Company has modified the XD-1 Bank "B" d-c supplies to bring their performance up to that required by the IBM purchase specification.

b. XD-1 Power Control System

The power control system of XD-1 has been unreliable since it was first installed. The troubles, which appear when power is being applied or removed from XD-1, have been almost entirely associated with two components:

(1) Heineman Sil-O-Kinetic time-delay relays and
(2) Struthers-Dunn control relays.

The Heineman Sil-O-Kinetic time-delay relay troubles have been considered to be trivial; these relays are in indicating circuits only and do not affect the control circuits which actually cause power to be applied to the electronic equipment.

The Struthers-Dunn control relays, on the other hand, are in the direct operating path of the central circuits so that a failure of one of these relays results in failure either to apply or to remove power. Failures are classified as follows:

(a) The relays are being used with d-c, although they were originally designed for a-c voltage coil operation. As a result, there is a tendency for residual magnetism to hold these relays closed after voltage has been removed.

(b) The mechanical design of the relay is such that the moving parts can bind with the result that they will not close when voltage is applied.

(c) The contact surfaces lie in a horizontal plane, and collect sufficient dust to prevent current flow after the relay is closed.

(d) The original design of these relays had no provision for the slight relative movement of the mating contacts (called "contact wipe") required in low voltage, low current, d-c applications to break down the very thin oxide film which forms on relay contacts. An attempt was made to correct this situation by Struthers-Dunn. Flexible beryllium-copper, contact-holding springs were substituted for the stiff copper bar that previously held the moving contacts. These springs do give contact wipe in XD-1, but their use on relays in the production machine can result in some relays with insufficient spring pressure unless extreme care is taken to insure that the final spring has been properly annealed.

The proposal to increase the reliability of the power system attacks the problem from two angles. The first is circuit redesign to eliminate as many relays as possible (including all the Heineman time-delay relays), and the second is to replace the remaining relays with a mechanically simple type made by Signal Engineering Company. The proposed relay is designed for d-c coil operation, has phosphor-bronze springs (which are not as critically dependent on annealing as is beryllium

copper), the contact surfaces lie in a vertical plane, and the contacts have excellent wiping characteristics.

c. Magnetic Amplifiers

Applications for magnetic amplifiers in computer power systems are being developed. A variety of low-voltage d-c power supplies for general laboratory use have been designed. An experimental magnetic amplifier, d-c voltage monitor will be used in place of Sensitrols in the Memory Test Computer. Studies are continuing in the use of magnetic amplifier logic circuits for control of computer power.

d. Thermistors

Thermistors, which are thermally sensitive resistors with large negative temperature coefficients of resistance, can be used for the gradual application of heater-voltage to thermionic tubes, thereby diminishing thermal transients and reducing mechanical failures. Full voltage is first applied to the thermistor and tube in series. After temperature equilibrium is reached, the thermistors are shorted out. One set of thermistors can be used to limit the current satisfactorily over a wide range of loads. Commercially available units in washer form can accommodate heater loads up to one kilowatt. Larger thermistors are being investigated in an attempt to use them for large loads.*

e. Transient Detectors

An all-vacuum-tube transient decoder was designed and installed which will detect any change of voltage greater than 5 per cent which occurs on the XD-1 d-c power distribution systems at the power control and distribution (PCD) frame. Another unit, which uses a mercury-contact relay as the detector, was developed for TX-2 to detect a-c transients.

R.J. Callahan	S.T. Coffin	A. Hingston
G.F. Sandy	F.R. Durgin	R.C. Jahn
B.W. Barrett	M.J. Flanagan	J. Malouin

D. DESIGN CONTROL OFFICE

All proposed changes to the equipment, computer program or operation of AN/FSQ-7 (XD-1), AN/FSQ-7, or AN/FSQ-8 are studied and recommendations made on them by the Design Control Office (DCO) which also obtains the necessary concurrence from the organizations concerned. Installation and availability dates for changes that are to be made to both prototype and production machines have been coordinated between IBM and Lincoln Laboratory to insure compatibility.

Our review of IBM rewrites, termed "S" documents, of present AN/FSQ-7 and AN/FSQ-8 specifications has continued; new and better specifications and adjustments have resulted, and most minor equipment incompatibilities that may hinder systems operation have been eliminated.

Addition of the inactivity alarm and a few minor wiring changes for consoles were the only changes made to XD-1 which affected programs.

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*G.F. Sandy, "Use of Thermistors for Limiting Currents to Vacuum Tube Filaments," MIT Lincoln Laboratory Report 6M-4595 (18 September 1956).

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The following items have received MIT-IBM concurrence for AN/FSQ-7 and -8:

Documents describing the changes required to convert the radar data drum to a track data drum (AN/FSQ-8's only) were completed. IBM will submit the changes to the Air Force for final approval. Minor modifications to the control circuits for the camera on the situation display console were included in these change documents to make the system compatible.

"S" documents on display-console equipment specifications represent the results of a major effort to present a vast amount of display information in a reasonable form. The AN/FSQ-7 portion of the display-console specifications received IBM-MIT concurrence and will be published as IBM document S-68.

J. D. Crane
R. H. Gerhardt
S. B. Ginsburg
J. Giordano
A. Rupp

ADVANCE DEVELOPMENT

GROUP 63

Brown, D. R., Leader

Best, R. L.
Bradspies, S.
Brown, D. L.
Clark, W. A., Jr.
Corderman, C. L.
Croft, W. J.
Davidson, G. A.
Dugger, C.
Dwight, K.
Eckl, D. J.
Ellis, D. H.
Farley, B. G.
Fergus, Patricia A.
Forgie, J. W.
Frankovich, J. M.
Gilmore, J. T.
Goodenough, J. B.
Gould, R. H.
Guditz, E. A.
Gurley, B. M.
Kirk, C. T., Jr.
Konkle, K.
Loeb, A.
Maddocks, F. S.
Menyuk, N.
Mitchell, J. L.
Olsen, K. H.
Pacl, R. A., Jr.
Papian, W. N.
Petersen, M.
Peterson, H. P., Jr.
Raffel, J.
Santelmann, W. F., Jr.
Smith, D. O.
Weiss, G.
Wickham, D. G.
Wold, A.
Zieman, H. E.
Zopatti, R. C.

III. ADVANCE DEVELOPMENT
GROUP 63

A. SUMMARY

All 38 planes of the 256 × 256 × 38 memory for the TX-0 and TX-2 computer systems had been installed by the end of November. Cycle time for the first twenty planes installed was initially 7.5 μsecs but was reduced to 6.5 μsecs. It is expected that the minimum time required between references (cycle time) will eventually be brought down to 6.0 μsecs.

Experimental print-wired, 4 × 4 (16 cores) memory planes have been fabricated at the rate of two per hour, which is considerably faster than current production methods for conventionally wired planes. Electrical characteristics of the printed planes are essentially equivalent to those of conventional planes. Present commercial photographic techniques have been combined with the use of a collimated light source; the practicality of producing memory planes by this method has been adequately demonstrated.

New display line drivers have been designed and installed in XD-1, replacing the original installations which did not meet rise time specifications. The new design meets all specifications with good margins.

Some of the needed equipment has been obtained for further study of evaporated magnetic films and their application as high-speed memory elements. A new traveling-wave-tube oscilloscope has been received from Edgerton, Germeshausen and Grier which will permit detailed viewing of the 1- to 10-mμsec pulses that are anticipated. Equipment was received during the quarter for continuously observing the anisotropy constant both during and after deposition. An instrument is being built for checking the hysteresis loops of thin films placed in a uniform, 1000-cycle field of 20 oersteds.

D. R. Brown
W. N. Papian
C. L. Corderman

B. MAGNETIC MATERIALS

1. Introduction

The magnetic materials section has concentrated on three major studies in its efforts to develop better magnetic materials for use in the components of the digital computers used at Lincoln Laboratory for the solution of real-time control problems:

(a) Evaporated magnetic films of nickel-iron alloy for faster memory operation,

(b) Oxide systems to learn about the fundamental relationships between chemistry and the magneto-electric properties of magnetic ceramics,

(c) The production facility transition from standard F-397 (50-mil ID, 80 mil OD) to smaller F-398 (30 mil ID, 50-mil OD) memory cores for use in transistor-driven memories.

2. Evaporated Magnetic Films

A coincident-current memory element is desired that will operate substantially faster than the ferrite core. The high-speed, low-power potential of thin films has been demonstrated,

although actual output voltages from switching films have not yet been compared in detail with the theoretical predictions for them. It is hoped that these comparisons can be completed during the next quarter. A new traveling-wave-tube oscilloscope has been obtained from Edgerton, Germeshausen & Grier which will permit detailed viewing of the 1- to 10-mμsec pulses that are anticipated. Present equipment is not fast enough for viewing the extreme speed of these films.

a. Domain-Wall Rotation

Magnetization reversal in a ferrite core proceeds by a sequential rotation of electron spins as a domain wall moves through the material. A shorter reversal time would be achieved if instead, a simultaneous rotation took place. To obtain a simultaneous rotation, a geometry must be chosen in which no demagnetizing-energy barrier exists between the two opposite states of magnetization. Thin films satisfy this requirement, since the demagnetization energy normal to the film will keep the magnetization in the plane of the film and no angular dependence of demagnetization will exist within this plane.

A theory was worked out which describes the rotational behavior of thin magnetic films.[1] A static and dynamic theory describes the behavior of thin magnetic films having a uniaxial anisotropy energy, $E_k = K \sin^2 \Theta$, and predicts a reversible hysteresis loop, transverse to the axis of lowest anisotropy energy, with saturation at a field of 2K/M. The loop that is longitudinal to this axis is square with a coercive force of 2K/M. A transverse d-c field will reduce the coercive force of the longitudinal loop and may lead to asymmetrical loops if the magnetic axis is not kept perpendicular to the d-c field. The dynamic theory, based on the Landau-Lifshitz equation, considers the application of impulse fields. The theoretical expression for the relaxation time depends on the direction of the impulse field with respect to the anisotropy axis. The relaxation time varies from ∞ to 1 mμsec as the angle between the impulse field and the magnetic axis varies from 0° to 90°. Processes can be both reversible and irreversible during this variation.

Using the equipment described in the previous quarterly report,[2] both reversible and irreversible rotational processes were observed in the time ranges predicted by the theory. The measurements obtained are being refined to check the theory in detail.

Equipment was received at the end of the quarter with which the anisotropy constant, K, can be continuously observed both during and at any time after deposition.

The experimental facts obtained to date, with regard to domain walls in thin films, do not correspond to any theory presently available, e.g., the wall coercive force is strongly dependent upon the composition. (Present theory predicts that the coercive force should be largely dominated by geometry and only slightly affected by composition). Experiments have also disclosed that slight differences in the cleaning procedure for the glass substrate, onto which the material is vacuum-evaporated, can strongly influence the coercive force of the wall. It is not clear yet why this is so.

An instrument is being built for checking the hysteresis loops of thin films. The film will be placed in a uniform 1000-cycle field of 20 oersteds. The wall coercive force, H_w, will be measured to an accuracy of approximately 5 per cent.

3. Oxide Systems

Three oxide systems were studied to investigate the correctness of the Zener double-exchange hypothesis and to learn more about the chemistry of manganese and its relationship to magnetism. These systems have never before been synthesized. In the system, $Ge^{+4}Co_2^{+2}O_4 - ZnMn_2^{+3}O_4$, Co^{+2} and Mn^{+3} are randomly present on similar lattice sites and preliminary measurements made at 42°K indicated the presence of magnetism in this system. Similarly, in the system, $Ge^{+4}Mn_2^{+2}O_4 - ZnMn_2^{+3}O_4$, Mn^{+2} and Mn^{+3} ions are both randomly present on the octahedral sites of the spinel lattice. Therefore, the criterion for the occurrence of ferromagnetism via double-exchange was established. These materials are not ferromagnetic at room temperature. Precise magnetic measurements will be made on them during the next quarter. These two systems are of further interest because they show lattice distortions from cubic to tetragonal symmetry which increase as the percentage of Mn^{+3} is increased – the distortions first occur at room temperature in materials with about 50 mol per cent $ZnMn_2O_4$. These results agree satisfactorily with the theory of covalent bonding (in second approximation) and semi-covalent exchange put forward earlier in memorandums 6M-2474[3] and 6M-3184[4].

The rock-salt-type system, $Li_xNi^{+2}_{(1-2x)}Ni_x^{+3}O$, was difficult to prepare. Measurements of the magnetic moment at 4.2°K indicated that the double-exchange mechanism does not operate in this system either. However, ferrimagnetism has been observed in materials with $x > 1/3$. The magnetism in these materials appears to be due to an ordering of the Li^+ ions in alternate (111) planes. Detailed magnetic studies will be made during the next quarter.

In order to understand the mechanisms responsible for crystalline anisotropy in ferrimagnetic ceramics, a theoretical study of the antiferromagnetic rock-salt-type oxides MnO, CoO, NiO was made. This material is summarized in 6M-4743[5] and was presented at the AIEE Magnetic Conference in Boston this October. The work is currently being extended to spinel-type structures.

4. Vibrating-Coil Magnetometer

The vibrating-coil magnetometer (VCM) is proving to have all the flexibility and accuracy originally hoped for. It is expected that early in the next quarter it will be producing accurate data from 4.2°K to several hundred degrees above room temperature.

The circuitry used in conjunction with the VCM is being revamped to improve performance. An amplifier unit has been constructed which is peaked at the coil vibration frequency of 34 cycles/sec with an attentuation of greater than 60 db per octave of frequency. The response curve of this unit is shown in Fig. 63-1. A phase-sensitive detector, which will further enhance the signal-to-noise ratio, has also been constructed and will be in operation shortly.

The two-coil configuration has been replaced by a single, vibrating coil to permit sweeping the magnetic field. Preliminary experiments indicate that the noise level at the signal coil can easily be kept below 5.0 microvolts throughout the field range available with the magnet. The noise level at a fixed field is approximately 1.0 microvolt. This is considerably lower than any value previously obtained, but is still at least one order of magnitude greater than the thermal noise of the coil, which represents the ultimate noise level attainable.

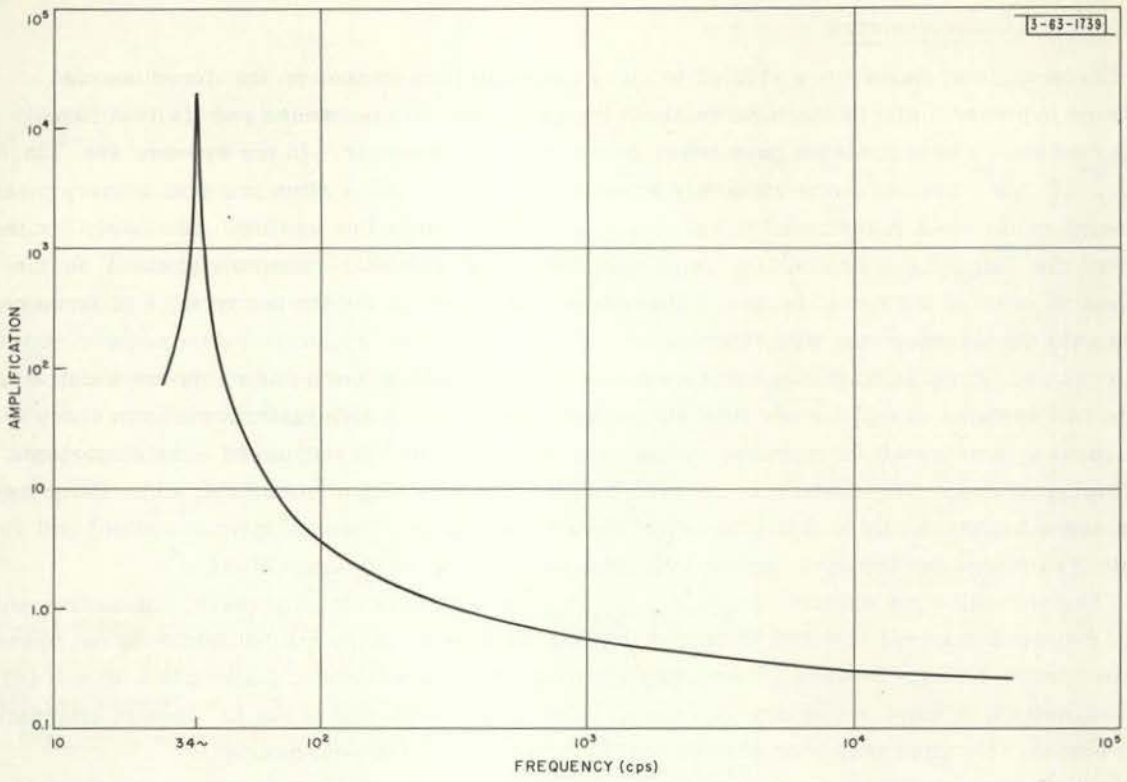

Fig. 63-1. Response curve, peaked amplifier unit of the vibrating coil magnetometer.

Auxiliary equipment designed for various experiments with the magnetometer in different stages of production include:

(a) Pumping system used with liquid helium to reach temperatures of 1.5°K,

(b) Carbon resistance thermometers to cover temperature range not handled by platinum thermometer (below 12°K),

(c) Sample-holding units for different experiments, which include magnetostriction anisotropy measurements below 4.2°K, and measurements immediately above the liquid helium temperature.

5. Ceramics

a. F-398 Memory Core Production

In the ceramics laboratory the production of F-397 cores for use in an expanded WWI memory was completed. Production was shifted to the smaller F-398 cores which are to be used in a transistor-driven memory. The biggest problem with the small cores has been the development of a semiautomatic tester. New test specifications also had to be worked out. The small cores have all been pressed on the single-stage Stokes press. New dies for the Colton rotary press have been ordered; it is hoped to have this press tooled up for production of the small cores during the next quarter.

b. Development

The ceramics laboratory has also been called upon to develop materials for three additional components: microwave devices, narrow-band filters based on the mechanical resonance of ferrites with large magneto-mechanical coupling coefficients, and thermistors. Since high density is an important property of microwave ferrites, processing procedures to increase the density have been investigated. Several magnesium-manganese and lithium-nickel ferrite bodies have been delivered to Group 35 for evaluation. Preliminary samples of nickel ferrite with small cobalt additions have been supplied for evaluation as filter elements. Preliminary thermistor bodies have not yet proved satisfactory.

The ceramics laboratory has also been attempting to find a ferrite composition which will retain its chemical composition while being fired at sufficiently different temperatures to yield wide variations in grain size. Various fluxing agents have been investigated for this purpose. It is hoped to study experimentally the relationship between grain size and the various engineering parameters which enter into computer design.

6. Rare-Earth Ferrites

A study of rare-earth chemistry has been started. Materials containing rare-earth elements form a completely new type of magnetic oxide which crystallizes in the cubic garnet-type structure. Materials of this type are expected to play an important role in microwave devices and samples will be delivered to the microwave section of Group 35 for evaluation during the next quarter.

Lanthanum rhodium oxide has been assigned an orthorhombic structure, with A = 5.46 Å, B = 5.59 Å, C = 7.92 Å. The percentage of lanthanum has been determined and corresponds with the calculated value for $LaRhO_3$. Lanthanum ruthenium oxide has been prepared by heating lanthanum oxide and ruthenium powder in air at 800°C for 24 hours, and then at 1100°C in an argon atmosphere for another 24 hours. The structure resembles that of $LaRhO_3$ and is now being studied crystallographically.

J. B. Goodenough
D. L. Brown
W. J. Croft
C. O. Dugger
K. Dwight
Elaine H. Keith
F. S. Maddocks
N. Menyuk
R. A. Pacl
D. O. Smith
G. Weiss
D. G. Wickham
A. Wold
R. C. Zopatti

C. TRANSISTORS

1. Life Tests

Early in September, the transistor laboratory was moved to new quarters which made it necessary to shut down the power for the life tests that were being run on surface-barrier transistors. The 442 transistors had, at the end of August,* operated a total of approximately 4,400,000 transistor-hours. The five failures (three in testing) resulted in a failure rate of

*These figures include all but those for the TM-1 multiplier reported in Section III, C, 3 of the previous Quarterly Progress Report[2], dated 15 September 1956.

about 0.1 per cent per 1000 hours. These transistors will be unsoldered from circuits and retested. The measurements that result from the retests will determine the desirability of reactivating the life tests.

Ten G. E. 4JD1A17 and ten Sylvania GT-903 transistors have been stored at 100°C for nine and five months, respectively. Some data on parameter changes should be available during the next quarter.

2. Transistor Switching Theory

We had shown that the principle switching parameters of a transistor, β_n, β_i, ω_n, ω_i, and τ_s, could be interrelated by an equation of the form

$$(\beta_n + 1) = \omega_n \tau_s \tag{1}$$

$$(\beta_i + 1) = \omega_i \tau_s \tag{2}$$

K. H. Konkle has further shown[6] that (2) agrees reasonably well with experimental data obtained from a group of Philco L-5122 surface-barrier transistors.

Now, (1) and (2) are derived from the valid relationships:

$$(\beta_{n,i} + 1) = \omega_{n,i} \tau_{n,i} \tag{3}$$

$$\tau_s = \tau_b \text{ (to a first order approximation)} \tag{4}$$

where τ_n, τ_i, τ_b refer to the bulk lifetime of the base region under various operating conditions such that by identifying τ_n and τ_i with τ_b we arrive at (1) and (2).

Further investigation[7] has shown that the assumed relations

$$\tau_n = \tau_i = \tau_b \tag{5}$$

hold only to a zero order approximation and that to a first approximation we have that

$$\frac{1}{\tau_b} = (1 - \Gamma^2) \frac{1}{\tau_n} + \Gamma^2 \frac{1}{\tau_i} \tag{6}$$

where Γ is a dimensionless and unknown function of the geometric structure of the transistor.

It can be shown, however, that Γ must lie in the range

$$0 < \Gamma < 1$$

and for "good" transistors it has been determined experimentally that $\Gamma \sim 1$. Consequently, we can write that

$$\tau_s \cong \tau_b \approx \tau_i \tag{7}$$

thereby accounting for the agreement of (2) with experimental data.

D. J. Eckl
Patricia Fergus
R. C. Johnston
C. T. Kirk

D. MEMORY

1. 256^2 Memory for TX-0 and TX-2

Early in September the first 20 planes of the 256 × 256 × 38 memory were connected to the TX-0 computer and operation was generally satisfactory. An inch-worm program was circulated for periods of one to two hours at a time. Minimum time required between successive references to the memory (cycle time) was at first 7.5 μsecs but was reduced to 6.5 μsecs as a result of the following two basic modifications:

(a) The digit-plane drivers were modified to select a quadrant of a digit plane instead of a whole one. A gating circuit was added from the memory address register in conjunction with the normal inhibit gate level.

(b) Careful selection of (1) shunt capacitors on the feedback diodes, and (2) the diodes themselves, corrected the faulty operation of some of the input amplifiers of the driving circuitry.

All 38 planes had been installed by the end of November. Figure 63-2 is a photograph of the memory installation which is shown as a system block diagram in Fig. 63-3.

2. Transistor-Driven Core Memory for TX-2

Two pluggable stacks, each 64 × 64 × 37 (4,096 cores), will be built for an entirely transistor-driven, core memory (TDCM) for TX-2. One stack will be assembled in the conventional manner (single planes soldered together), the other wired together in one piece. Wiring jigs are being built and a machine has been designed which is expected to simplify the stripping of wires for plane construction.

Each 4,096-word, 37-bit memory stack will be contained within a 5-inch cube. The ferrite cores for it are 47 mils OD, 27 mils ID, and 12 mils thick. The material is the same as that used for the cores in the 256^2 memory. Figure 63-4 is a block diagram of the TDCM. The basic circuits are schematically represented in Figs. 63-5 through 63-9. Figure 63-10 is a timing diagram for this memory in which words will be read out in parallel with a cycle time of 5.5 μsec and an access time of 2.4 μsec.

3. Index Memory for TX-2

This is the smallest and fastest of the three memory systems that have been designed for the TX-2 computer, and will be used to provide index registers and program counters. It will have a storage capacity of 64 19-bit words which will be read out in parallel with a cycle time of 4.0 μsec and an access time of 0.8 μsec. Two cores per bit and register selection will be used. The winding configuration for this single-plane, random-access unit is shown in Figs. 63-11 and 63-12. A block diagram of the complete memory system is given in Fig. 63-13 and the timing diagram in Fig. 63-14. Figure 63-15 is a photograph of the 64 × 38 memory plane. Figures 63-16 through 63-20 are schematic representations of the basic circuits of the index memory system.

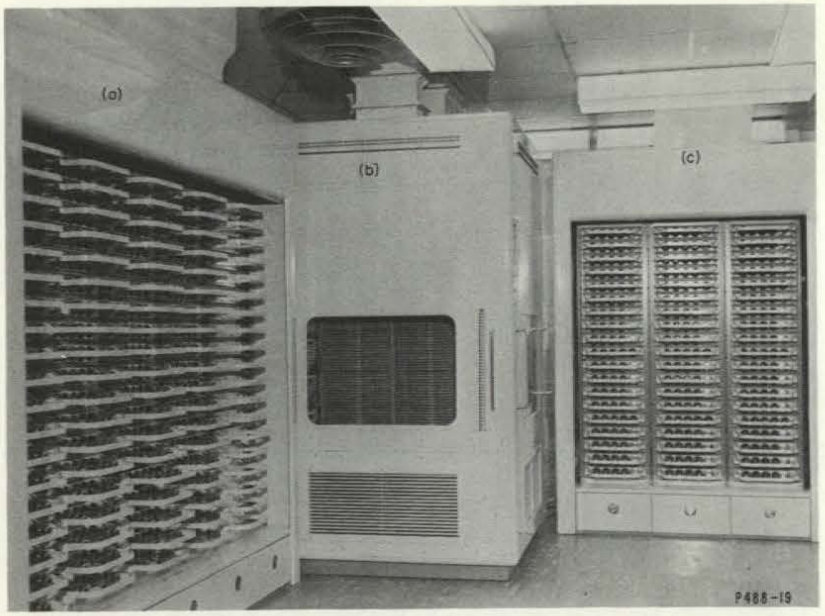

Fig. 63-2. 256^2 Memory: (a) digit-plane drivers and sensing circuits; (b) memory stall with memory planes and magnetic-core matrix switches; (c) matrix-switch driving circuits.

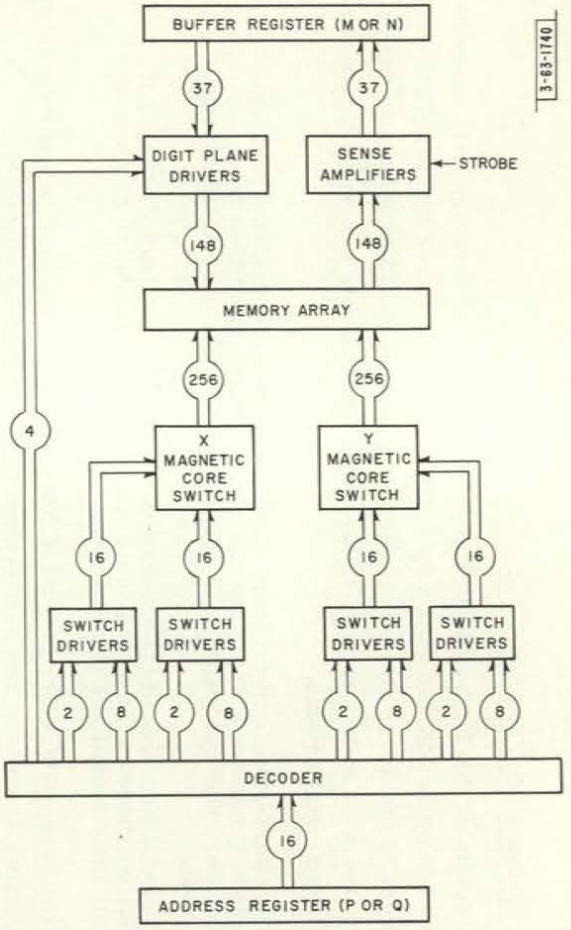

Fig. 63-3. 256^2 Memory, block diagram.

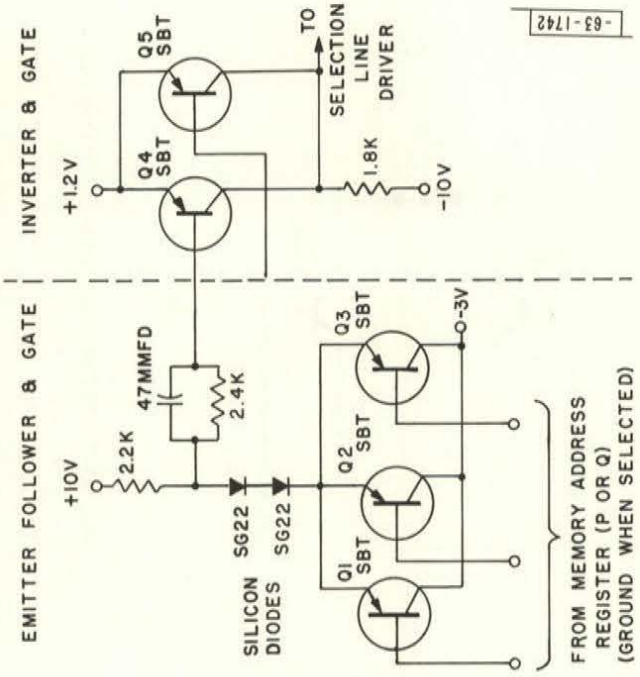

Fig. 63-5. TDCM, one-channel, emitter-follower and inverter AND gates.

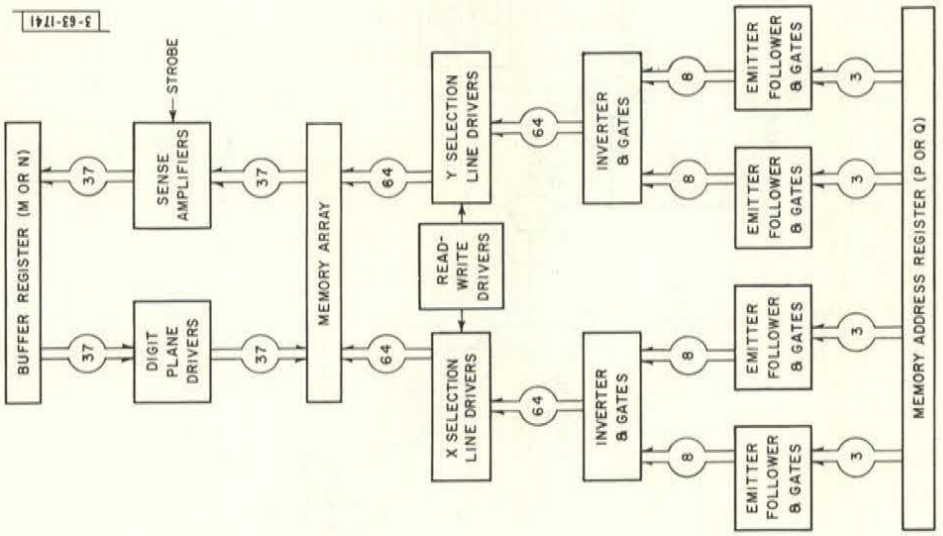

Fig. 63-4. Transistor-driven core-memory (TDCM), block diagram.

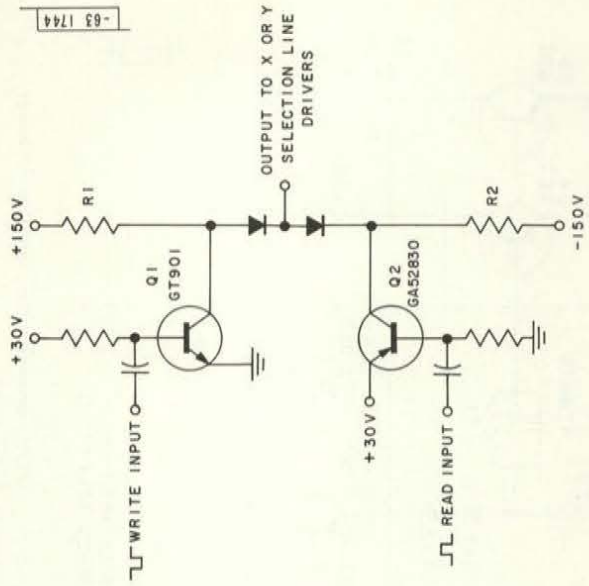

Fig. 63-7. TDCM, read-write driver (two needed).

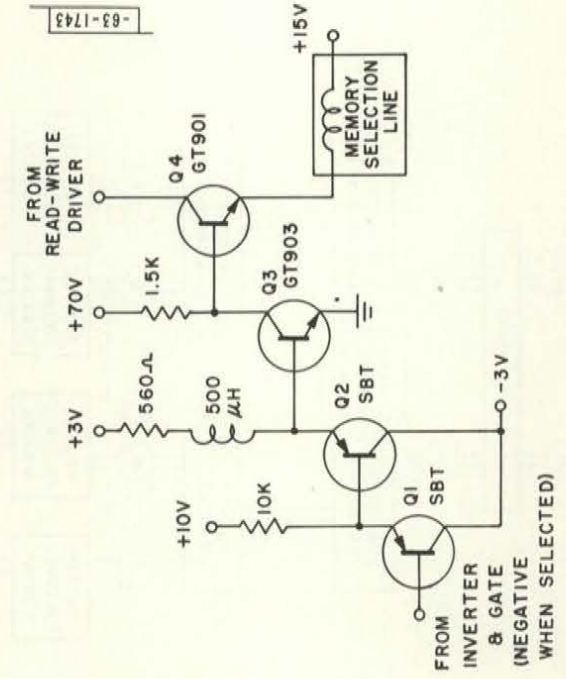

Fig. 63-6. TDCM, one-channel, selection-line driver.

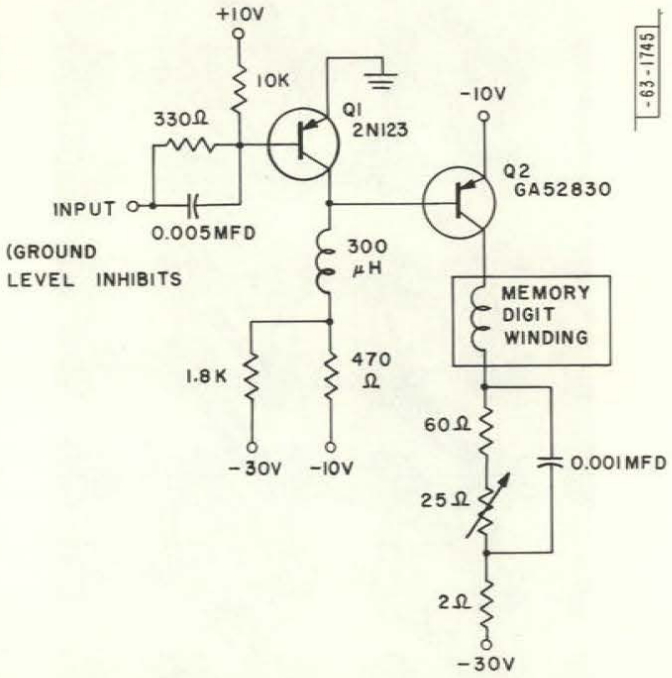

Fig. 63-8. TDCM, digit-plane driver.

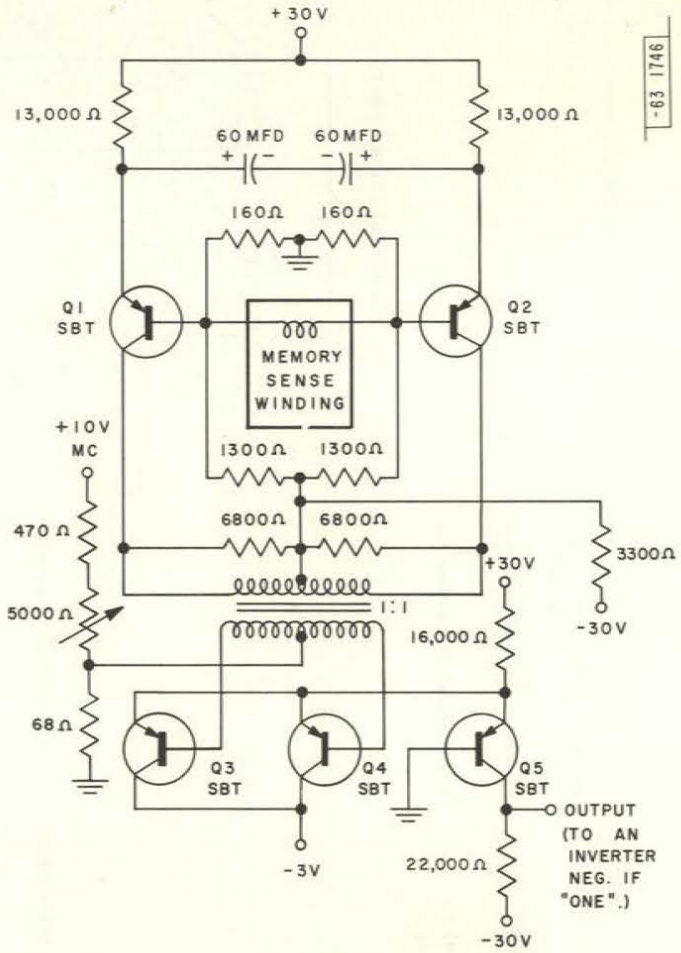

Fig. 63-9. TDCM, pulse-amplifier.

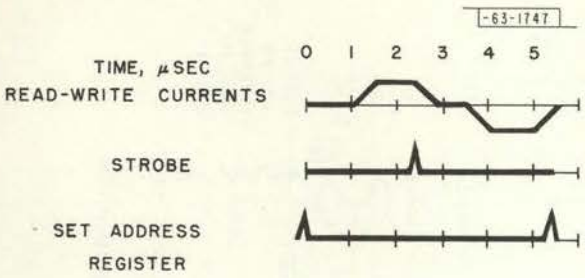

Fig. 63-10. TDCM, timing diagram.

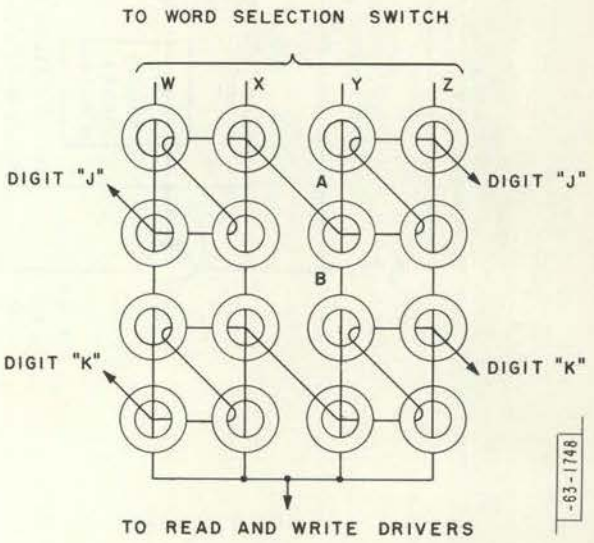

Fig. 63-11. Index Memory, winding configuration.

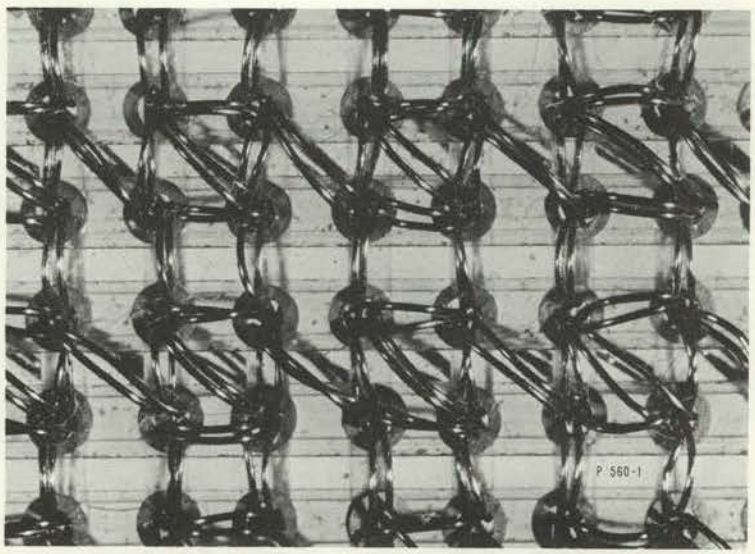

Fig. 63-12. Index Memory, section of memory plane enlarged.

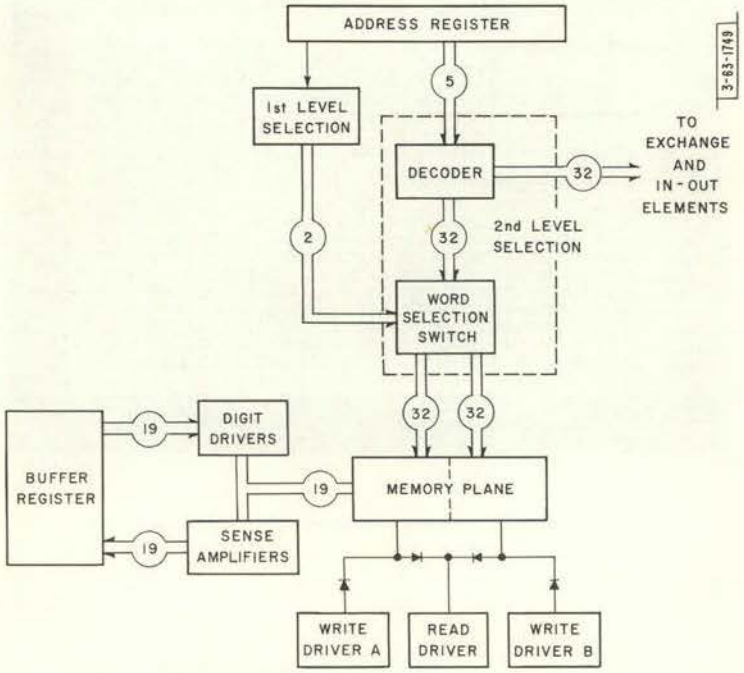

Fig. 63-13. Index Memory, block diagram.

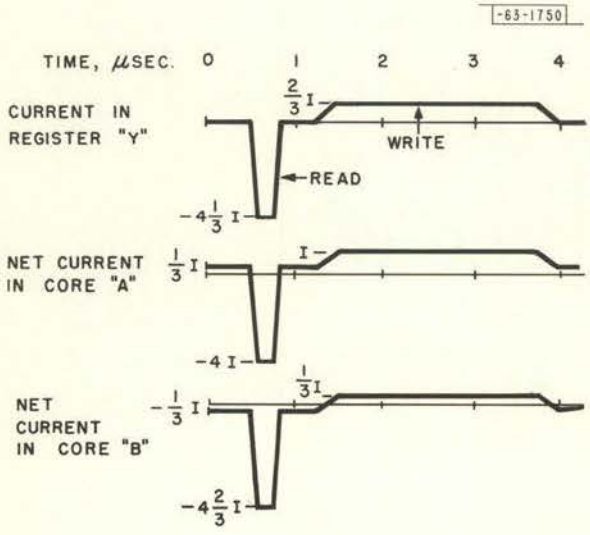

Fig. 63-14. Index Memory, timing diagram.

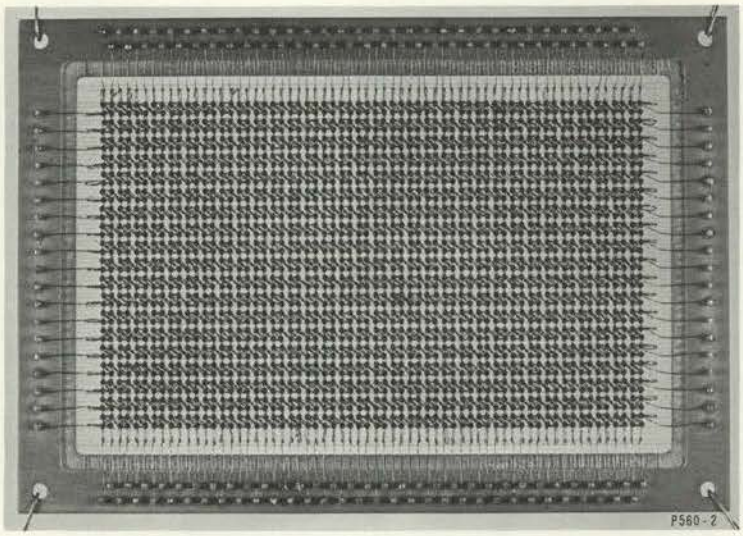

Fig. 63-15. Index Memory, 64 × 38 plane.

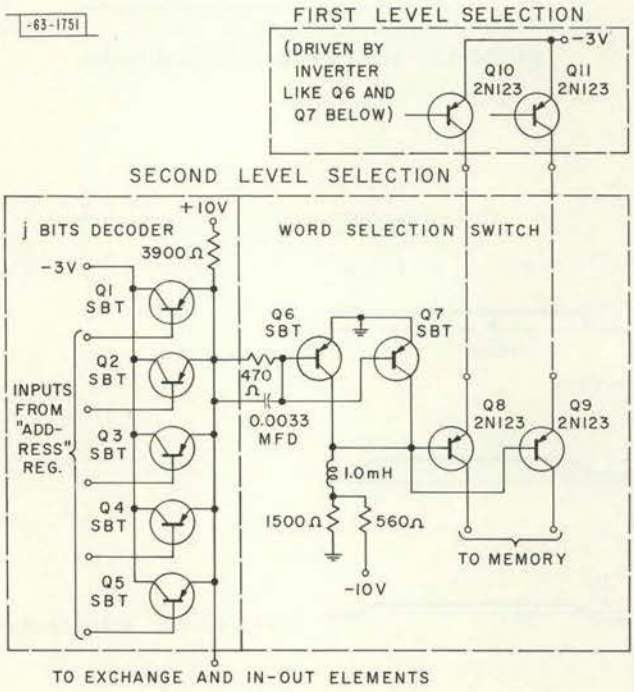

Fig. 63-16. Index Memory, register-selection circuit.

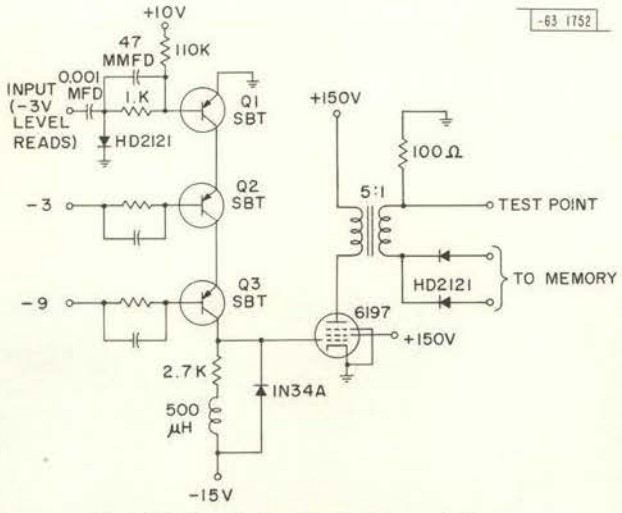

Fig. 63-17. Index Memory, read driver.

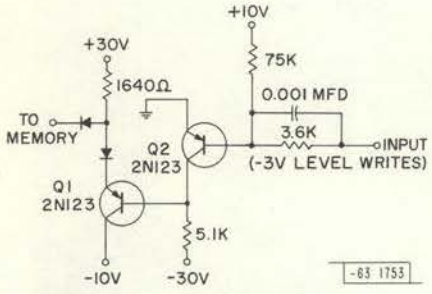

Fig. 63-18. Index Memory, write driver.

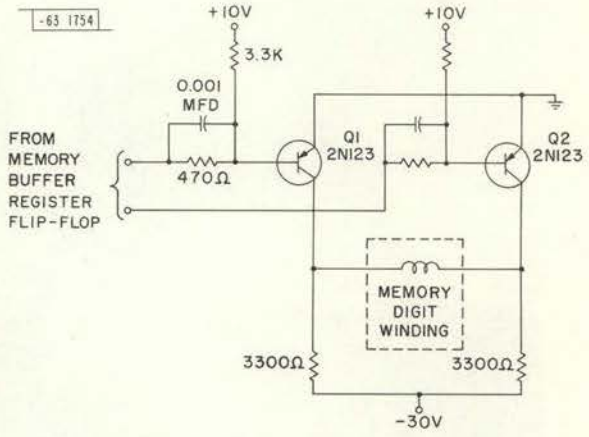

Fig. 63-19. Index Memory, digit driver.

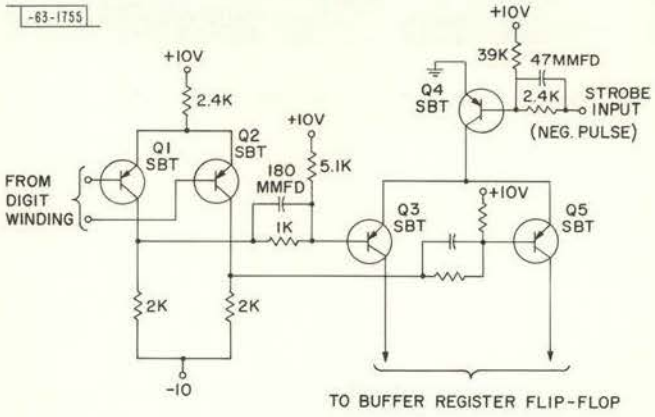

Fig. 63-20. Index Memory, sense amplifier.

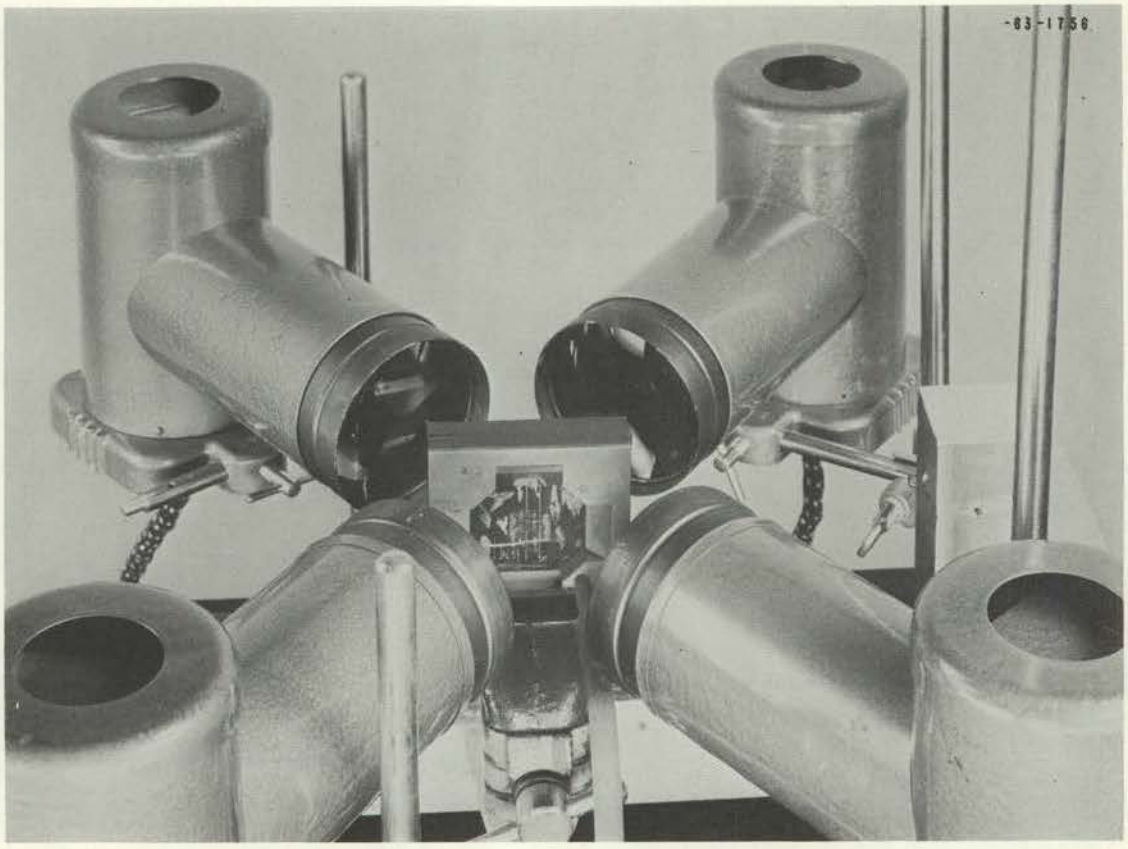

Fig. 63-21. Printing memory planes using collimated light.

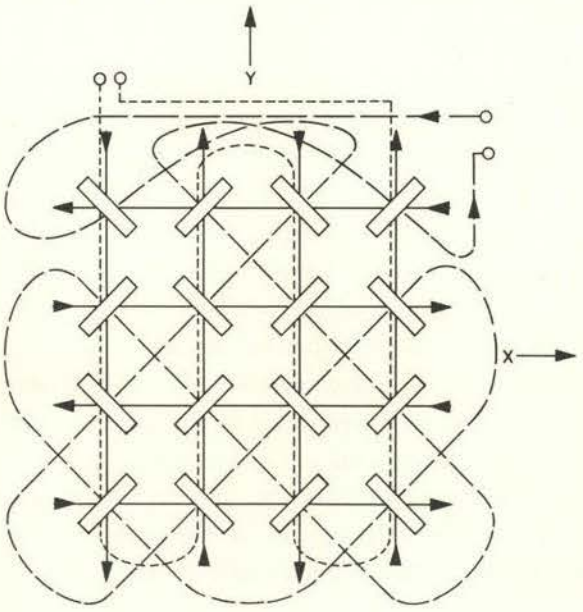

Fig. 63-22. Conventional wiring pattern.

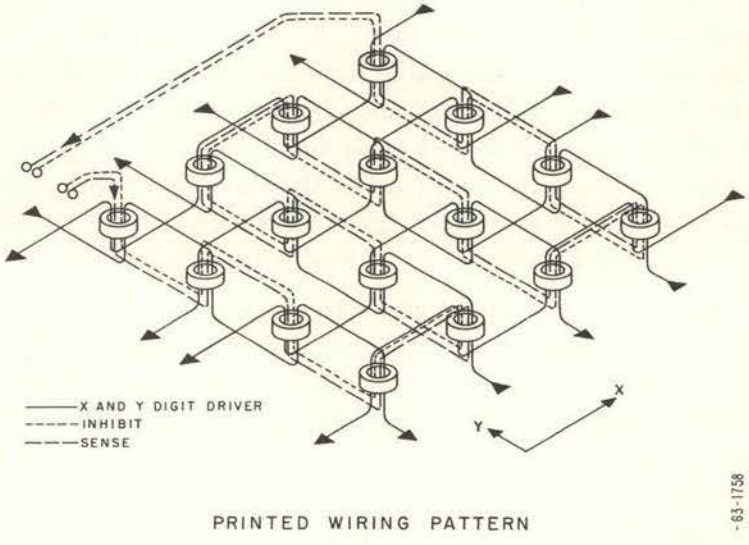

Fig. 63-23. Printed wiring pattern.

4. Printed Memory Planes

The practicality of producing memory planes by printed wiring techniques has been adequately demonstrated during this quarter. Sixteen-core (4 × 4) print-wired planes have been successfully produced using present commercial methods except for the use of the collimated light source (Fig. 63-21). The 4 × 4 planes have been fabricated at the rate of two per hour which is about 20 times faster than current production methods for conventionally wired planes, with no change in the electrical characteristics for planes of the same size. Since the printed-wiring method is completely amenable to automatic production methods, its ultimate speed is much greater. It is also reasonable to expect that automatic production will result in further improvement in the quality of memory planes due to the accuracy and uniformity inherent in the basic method. Because the cores are almost completely protected by the phenolic panel in which they are placed, there is negligible danger of core damage during processing.

Collimated (parallel) light, directed through an aperture mask at an angle to a photosensitive panel, projects an image which follows the contour of the panel. However, two problems had to be solved before this useful manipulation of light could be applied to the production of print-wired memory planes:

First, the intricate wiring pattern of conventionally wired planes (Fig. 63-22) had to be rearranged. The pattern initially developed for the x and y drive windings was satisfactory for basic 4 × 4 (16 cores) laboratory experiments. However, operational memories (16 × 16, 64 × 64, etc.) would require two additional windings (sense and inhibit). Since the x and y drive windings were alternately on the top and bottom surfaces of the plane, a great number of crossovers would result when the sense and inhibit windings are added, and the final arrangement of the wiring would not be compatible with existing driving circuitry. The patterns shown in Fig. 63-23 for x and y drive windings and sense and inhibit windings were developed in the General Engineering Section of Group 60 and are compatible with present driving circuitry. The patterns provide for the sense and inhibit windings to be on the top surface of the plane for quadrant connections. Only three crossovers are necessary and those occur only with the sense winding. No more crossovers than these will be necessary even for planes as large as 64 × 64 (4096 cores).

Second, a pair of masks had to be produced which would be held in accurate registration in order to join the front and back patterns with four connecting paths through the 50-mil hole in each of the cores. Several attempts were made before a set of satisfactory masks were obtained by photoengraving techniques. However, a selective masking technique has been developed by Group 60 which can economically produce masks with a line-center position accuracy of ± 0.001" from an outside reference line. The technique is based on the fact that a pair of parallel lines can be ruled to great accuracy and used to form appropriate segments of a wiring pattern by repeated exposures on a step-and-repeat table.

J. L. Mitchell
R. L. Best
S. Bradspies
G. A. Davidson
D. H. Ellis
E. A. Guditz

E. DISPLAY

1. Remote Display Consoles

The logic design of the system for the remote display consoles has been completed and many of the component circuits have been designed and are being packaged in standard TX-2 plug-in chasses. The system will use a special storage-type, character-display Typotron. Incoming information will be processed and directed immediately to the required display registers and the message displayed as it comes in. Although, in this system, if a parity occurs on a given message, a track that had already been displayed would have to be obliterated, the system can later be expanded to include extra storage so that track information can be examined and destroyed if necessary before being displayed. A core memory would store information on two tracks. While good information on one track is being displayed on the tube, new incoming information would be held in the memory.

2. Magnetic Deflection Yokes

A new, printed-circuit, magnetic-deflection yoke, developed by Stromberg-Carlson, has been tested for possible use in XD-1. Rise times in the order of 30 μsecs can be achieved with no adjustments whatever. No effects have been noticed from external fields and no eddy current problems exist. However, the yoke did show a considerable tendency to curve vectors and could not be accepted on this basis. It is felt that this problem can be overcome and its use with XD-1 would be promising.

3. XD-1 Display Line Drivers

New display line drivers have been designed and built and are being installed in the XD-1 display system. The display line drivers originally installed did not meet rise time specifications and were found to have poor margins in other respects. The new design was completely tested with both simulated and actual display loads and met all present specifications with good margins. The driver receives a voltage signal from a display decoder, amplifies it 3.6 times, and feeds the output to all display consoles, in parallel, through approximately 1700 feet of cable.

4. Phosphor Studies

A Charactron with a P25 phosphor and a special Cathode-ray tube with six different phosphors placed in pie-shaped segments are being studied to determine which phosphor is best suited for the long persistence required of tracks and the short persistence of messages during track-monitoring operations. The studies will be conducted using the Memory Test Computer.

5. New Clocks for XD-1

A new clock has been designed for the display areas of XD-1 as a result of further studies of the lighting system of Building F. The clocks are scoreboard-type with filters to cut intensity. They are big enough to be clearly seen from any part of the area and yet dim enough so that there will be no serious reflection from the nearest console tube face.

H. E. Zieman R. H. Gould
J. Kriensky W. F. Santelmann

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2. MIT Lincoln Laboratory Quarterly Progress Report (15 September 1956).

3. J. Goodenough, and A. Loeb, "A Theory of Ionic Ordering, Tetragonal-Phase Formation, Magnetic Exchange, and Lamellar Precipitation Due to Covalent Forces in Spinels," MIT Lincoln Laboratory Report 6M-2474 (7 May 1954).

4. J. Goodenough, "A Theory of Perovskite-Type Manganites," MIT Lincoln Laboratory Report 6M-3185 (30 November 1954).

5. J.B.Goodenough, and A.L. Loeb, "Anisotropy in Antiferromagnetic Crystals with the Rock-Salt Structure," MIT Lincoln Laboratory Report 6M-4743 (October 1956).

6. K.H. Konkle, "Hole Storage in a Saturated Grounded-Emitter Transistor Circuit," M.S. Thesis, MIT (to be published).

7. C.T. Kirk, "Some Notes on the Theory and Design of Alloy Junction Transistors for Switching Purposes – Part III" (to be published).

ESS TEST PLANNING – WWI MTC OPERATION

GROUP 64

Rich, E. S., Leader

Allen, D. F.
Aufderheide, D.
Brooks, Emy
Bryan, Jean C.
Buzzard, R. D.
Cahill, J. J., Jr.
Callahan, T. R.
Case, A.
Chomsky, Carol
Daggett, N. L.
Decof, D.
Earl, Lois M.
Fitzpatrick, Virginia
Gates, E. K.
Glover, E. B.
Grandy, C. C.
Healy, L. D.
Hodder, J. C.
Holmes, L.
Hudson, Nancy
Hughes, A. D.
Jones, N. T.
Lafferty, E. L.
Lin, C. S.
Mercer, H. F.
Monahan, J.
Morrison, D. A.
Murphy, P. J.
Nichols, J.
Norcott, L. H.
Ockene, N. J.
Ogden, W., Jr.
Pughe, E. W., Jr.
Rowe, A. J.
Russo, R. F.
Small, C. E.
Stockebrand, T.
Stylos, P.
Thomas, D. J.
Vanderburgh, A.
Woodward, W.
Ziegler, H. L.

IV. ESS SHAKEDOWN TESTING – WWI MTC OPERATION
GROUP 64

A. SUMMARY

The first phase of shakedown testing of the Experimental SAGE Subsector (ESS) will begin on 3 December 1956. Specifications for the tests to be conducted during the first few weeks have been written, covering simulated-input radar data from both magnetic tape and from the manual simulation facilities of the training and battle simulation (TBS) room. These tests have been designed to check out the simulation facility of the system, to examine manual initiation and automatic tracking, and to introduce operating personnel to the system.

Three sections have been established within the group (1) to plan the shakedown tests, write the test specifications for them, and supervise the conduct of the tests; (2) to write the computer programs for the Memory Test Computer that will simulate the necessary input data and reduce for analysis the test data obtained; and (3) to determine the test data that should be obtained from shakedown tests and to investigate system operation by analysis of this data.

The reliability of the Memory Test Computer is important to the support of both ESS and CCS (Cape Cod System) test activities. Steady improvement in MTC's performance is a major objective and the following areas are under study: (1) Investigation of the magnetic tape system was completed and modifications to improve its performance are being made. (2) The central computer equipment (arithmetic element) is being studied. (3) Marginal checking facilities have been improved, and circuit weaknesses, discovered as a result, are being corrected. (4) Diode testers were developed which improve the checking of diodes. (5) Changes made to the display camera have reduced its indexing time from 1400 to 475 milliseconds. (6) A new input mixer unit has been developed. The unit is much smaller than those now used and will need little of the rack space presently taken up by the old units. (7) A closed-loop TV system is being studied as a possible device for reading visual information directly into a digital computer.

Modifications to the Whirlwind I computer facility are being made as a result of the approved plans for expansion of the Cape Cod System. Those modifications installed and operating include an increase of core memory by 4096 registers; addition of equipment for handling FST-2 data (i.e., long-range radar and height-finder data) from Bath and similar data from South Truro; and some relocation of equipment in the Cape Cod direction center.

E.S. Rich

B. ESS SHAKEDOWN

The first ESS shakedown test is scheduled for 3 December 1956. The test specification covering this test and those of the first few subsequent weeks have been written. Initial tests are designed to check out the simulated input facilities for radar data from both magnetic tape and the manual simulation facilities of the TBS room. The tests will also provide data for analysis of the automatic tracking and manual initiation features of the system, introduce operating personnel to the system and prove out the testing techniques used. The test specifications are based upon the questions asked in 6M-4281, "General Shakedown Test Requirements," and the tests will

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use package A of the DCA program. Package A contains the computer programs for the radar inputs, automatic tracking, manual track initiation, operational recording, and simulation functions and has been assembly-tested and adapted to ESS by Group 67.

The review of all planning for ESS shakedown testing continued and the first revision to the "General Shakedown Test Requirements," 6M-4281 was written. This memorandum establishes criteria to verify that operational, mathematical, and equipment specifications have been followed, and will raise specific questions on which to base test specifications. ESS system shakedown testing will provide a working subsector which will permit Group 22 to begin their evaluation testing.

Three sections were established within the group to (1) plan tests, (2) write the necessary supporting computer programs, and (3) analyze results for shakedown testing. The responsibilities of these three sections have been detailed in 6M-4124-1, "Organization and Responsibilities of Group 64," and are briefly as follows:

1. Test Planning

This section will write the necessary test specifications and supervise the conduct of the system shakedown tests.

2. Programming

Computer programs for the Memory Test Computer will be written to simulate radar data inputs and to reduce for analysis the data received from system shakedown tests.

3. Test Analysis

This section will carry out analyses of reduced data to verify power implementation of system design specifications. When observations and analyses indicate improper system behavior, diagnoses will be made to determine causes of such behavior so that corrective action can be taken.

J. J. Cahill, Jr.	Lois M. Earl	W. Ogden, Jr.
C. C. Grandy	Virginia Fitzpatrick	E. W. Pughe, Jr.
Emy Brooks	J. C. Hodder	R. F. Russo
Jean C. Bryan	Nancy Hudson	P. Stylos
R. D. Buzzard	E. L. Lafferty	D. J. Thomas
T. R. Callahan	C. S. Lin	A. Vanderburgh
A. Case	J. Monahan	W. Woodward
Carol Chomsky	J. Nichols	

C. MEMORY TEST COMPUTER

Steady improvement in MTC's performance and reliability is a major objective, because of the importance of MTC to the testing activities of both ESS and the Cape Cod System. The following studies and improvements have been or are being made:

1. Magnetic Tape System

The investigation of the magnetic tape system has been completed and the report issued.* It was discovered that, if the time constants within the amplifier circuits were increased, a gain

*T. C. Stockebrand, "Results of Investigation to Improve Reliability of the MTC Tape System," MIT Lincoln Laboratory Report 6M-4764 (4 November 1956).

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by a factor of 2 in signal-to-noise ratio was obtained in the read amplifiers of the system. The longer time constants decrease pulse droop and, thus, decrease pulse overshoot, which is the main source of noise. However, with the new time constants, the read amplifier would not recover from "write" transients in time for the desired signals; it was necessary, therefore, to gate out the inputs to the amplifier during "write" time. A special transistor gate circuit was designed for this purpose.

One of the three tape drives of the system has been modified to test results of the investigation. The other two will be modified in accordance with the results of the test.

Actual destruction of information on the tape seems to be a minor source of error, but build-up of oxide on the head was found to contribute to tape errors. A special test was performed to compare results of standard tape with lubricated tape. Results of the test were that lubricated tape would make about 2000 passes through the head before making the first error. The lubricated tape, however, was still considered usable because error-free results were obtained on subsequent readings. The best tape was worn out at 60,000 passes – the worst at 20,000. Standard tape made about 1000 passes before the first error and was considered worn-out between 4000 and 5000 passes.

2. Marginal Checking System

New forms have been designed that are compatible with the newly installed margin-selector switches. These switches permit checking margins without actually going to the failure point. Deteriorating circuits were uncovered as a result of improvements to the marginal checking system, as was the need for improvement of other circuits, by retermination of pulses and logic changes. Charts are now available for graphically plotting marginal checking histories directly.

3. Diode Checking

Three testers, incorporating a circuit for testing the dynamic characteristics, pulse drop, and reverse recovery were constructed and improved diode checking has resulted.

4. Display Camera

Indexing time of the display camera was reduced from 1400 to 475 milliseconds by the design of a new camera control panel. The design incorporated the following two features:

a. The time required for operation of the relay control was reduced to take advantage of the capabilities of the camera. A more rigid camera mount keeps the system from vibrating at the increased speed. Display instructions used without the camera will not be affected.

b. Pushbuttons have been added to the maintenance console for manual indexing of the camera.

5. Input Mixer Units

Drive pulses are supplied to individual buffers from many sources. Each line is connected to the buffer through a diode which provides isolation from other lines connected to the same buffer. A new input mixer unit has been designed which provides for greater than six times the number of inputs accommodated by the present unit. The diodes are packaged in a much smaller space, allowing simpler mounting techniques.

New microribbon connectors made it possible to design a plug-in unit containing 32 diode inputs with one output jack for each group of 8 diodes. A single unit thus provides up to 4 independent mixing circuits, each capable of accommodating 8 inputs (Fig. 64-1).

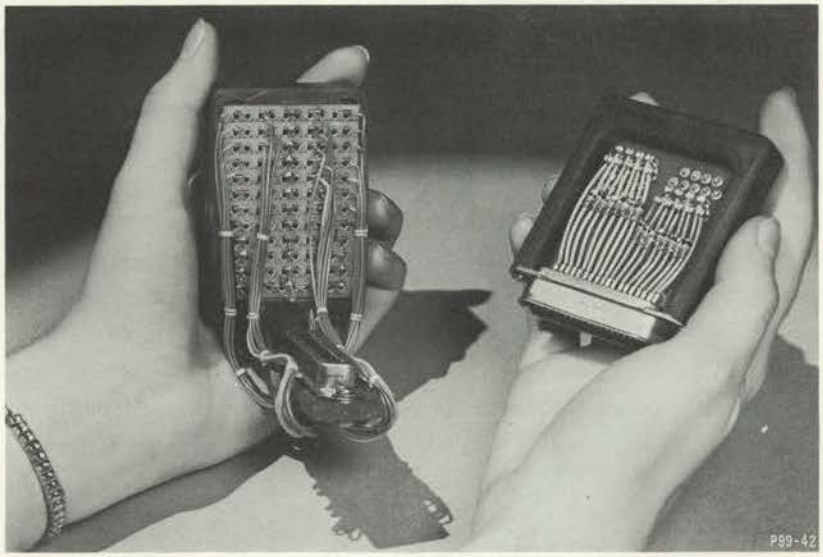


Fig. 64-1. New input-mixer plug-in unit.

The problem of cable connectors to the outputs of the plug-in units was solved by the use of taper-pin connectors. These connectors are very small and can be packed much closer together than the conventional coaxial cable connectors which must have enough free space around them to allow a finger-grip (Figs. 64-2 and 64-3).

In initial designs of the diode plug-in units, crosstalk of as much as 9 volts was observed at one output when a 45-volt pulse was applied to the other three mixer sections. Nine volts is enough to switch a flip-flop under some conditions, and the crosstalk was reduced to 2.5 volts or less by a change in bus wiring and relocation of the wiring on the underside of the plug-in unit. A test was performed on the plug-in unit using the test circuit shown in Fig. 64-4.

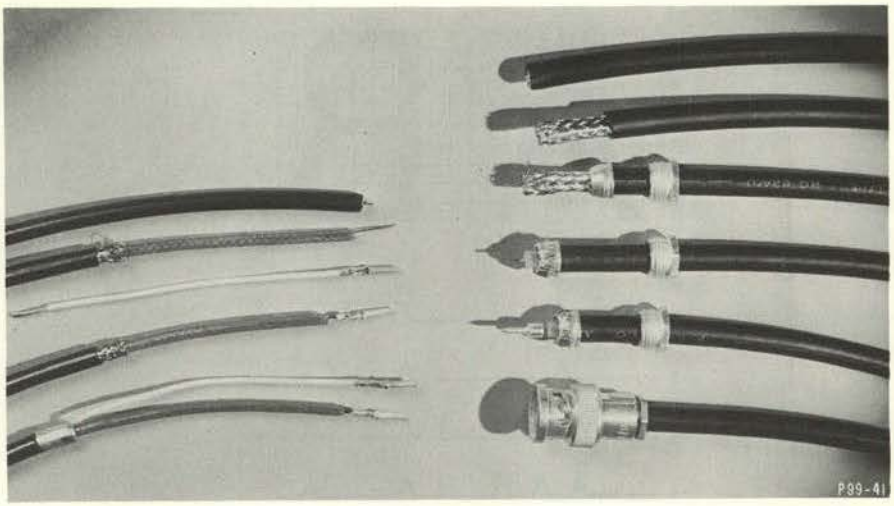
The new units fit between circuit connectors on the mounting panels and require none of the rack space used by the present pulse mixers. The rack space thus saved will be used as cableways for easy maintenance.

Packaging for the new unit was designed* for quantity production and 14 plastic prototype assemblies were made for wiring and testing. It is expected that MTC will use several hundred units.

6. TV Computer Input System

A closed-loop television system is being studied as a possible computer input device for reading visual information, such as a printed page or a scope display, directly into magnetic

*MIT Lincoln Laboratory Quarterly Progress Report, Section VIII, B., 7 (15 September 1956).



(a) (b)

Fig. 64-2. Input mixer cabling showing steps in assembly (a) new cables using taper-pin connectors (b) present cables using conventional connectors.

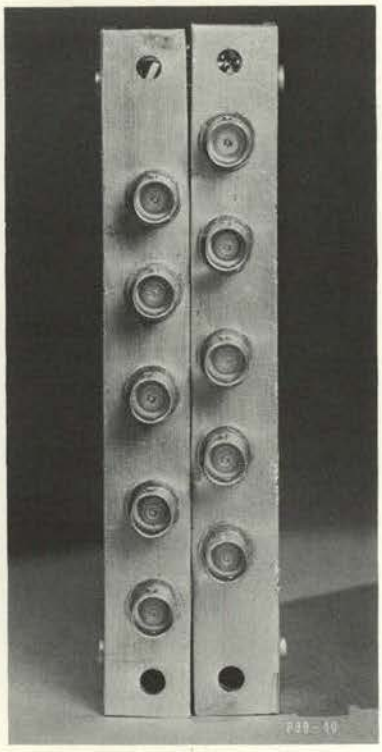


Fig. 64-3. Present input-mixer unit showing method of assembly to allow finger-grip.

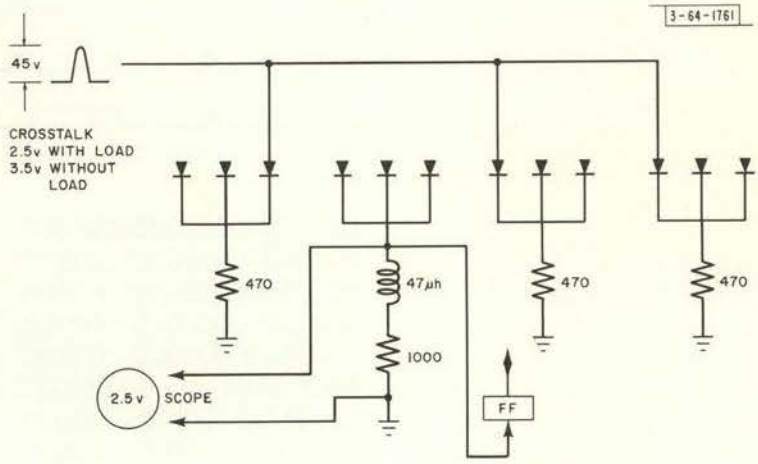


Fig. 64-4. Test circuit for new input-mixer.

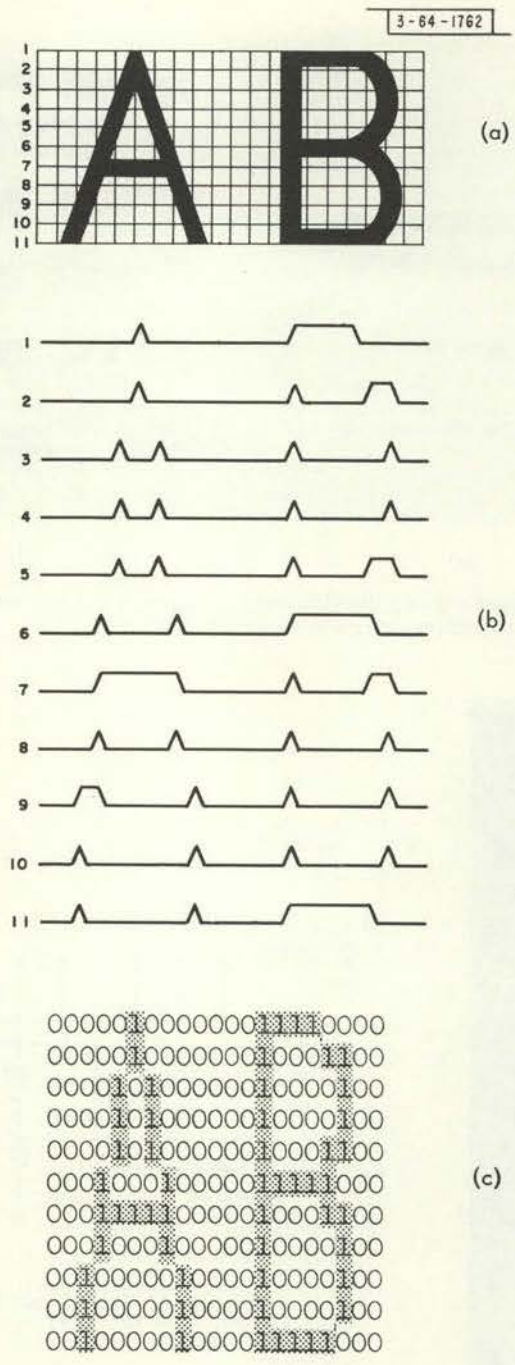


Fig. 64-5. Conversion of visual information to digital: (a) representation of a quantized segment of a printed page; (b) representation of the waveforms received by scanning each of the horizontal coordinates; (c) reconstruction from (a) and (b), substituting ONES and ZEROS for pulse and no pulse, respectively. The letters A and B are readily recognized.

tapes, magnetic drum or core memory of a digital computer. The need for punched tapes or cards, or tape-to-card converters would thereby be eliminated. The system being contemplated is one in which a television camera would scan a printed page and the video information would be processed into digital information by an auxiliary circuit. The vertical coordinates for resolving a video pattern into digital data are obtained by counting the horizontal lines of the video pattern; the horizontal coordinates, by sampling each horizontal line at discrete intervals and counting the intervals. Figure 64-5 describes the conversion of visual information to digital.

The auxiliary circuit, called a "quantizer," has been designed. The quantizer will sample the horizontal lines of the video pattern on the basis of time increments, thereby converting the video waveforms into a configuration of pulses [see Fig. 64-5(a) and (b)] that are acceptable to a digital computer system.

H. L. Ziegler
D. Decof
E. B. Glover
A. D. Hughes
N. J. Ockene
C. E. Small
T. Stockebrand

D. CAPE COD ENGINEERING

1. WWI Expansion

WWI is being modified as a result of the approved plans for expansion, formulated by Group 22, to make the Cape Cod System (CCS) a more useful tool for experimentation and evaluation of air defense functions. Modifications are expected to be completed by 15 December 1956, and checked out and ready for CCS operation by 1 February 1957. Status of equipment changes to be made by the Cape Cod Engineering Section is as follows:

a. Search and Height-Finder Radar Inputs

Modification of WWI to receive data from the FST-2 equipment installed at Bath is essentially complete and is being used on a regularly scheduled basis. To provide for the long-range radar input (LRI), a 450-plug-in-unit installation was added to WWI that is capable of accepting a saturated phone-line transmission rate of 300 messages over each of two phone lines during each 6-second computer program subframe (Fig. 64-6). The programming requirements for the WWI – FST-2 input system for Bath, Maine, have been issued in 6M-4418.

The WWI crosstelling equipment was modified to transmit program-generated semiautomatic height requests to Bath, Maine, and South Truro, Mass., by adding 50 additional plug-in units. The crosstelling feature can be restored easily if necessary. The new system will accept a 5-word height request from the computer, and will interleave the words while using about 250 μsecs of computer time; the system can be used at the rate of 140 milliseconds per request.

The Lincoln Laboratory fine-grain data (FGD) equipment at South Truro will probably be retired from service at the end of 1956 when FST-2 equipment becomes available. CCS overlap coverage tests will be continued by using heavy radars at both Bath and South Truro. Equipment for handling FST-2 data from South Truro, similar to that for Bath, was added to WWI (a 350 plug-in unit required).

By the end of November, the first of two South Truro input channels had been tested with a WWI computer program. The installation was expedited by disabling one of the Bath input

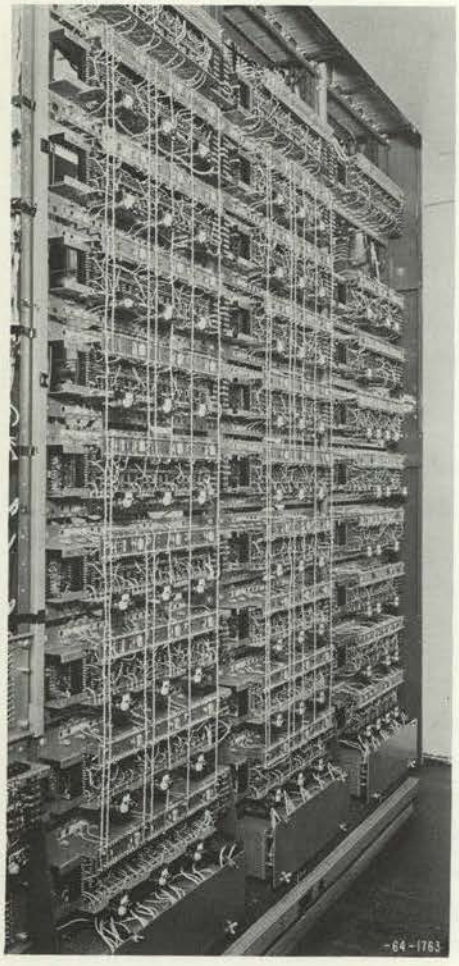


Fig. 64-6. Whirlwind I 450-plug-in unit installation for long-range radar input.

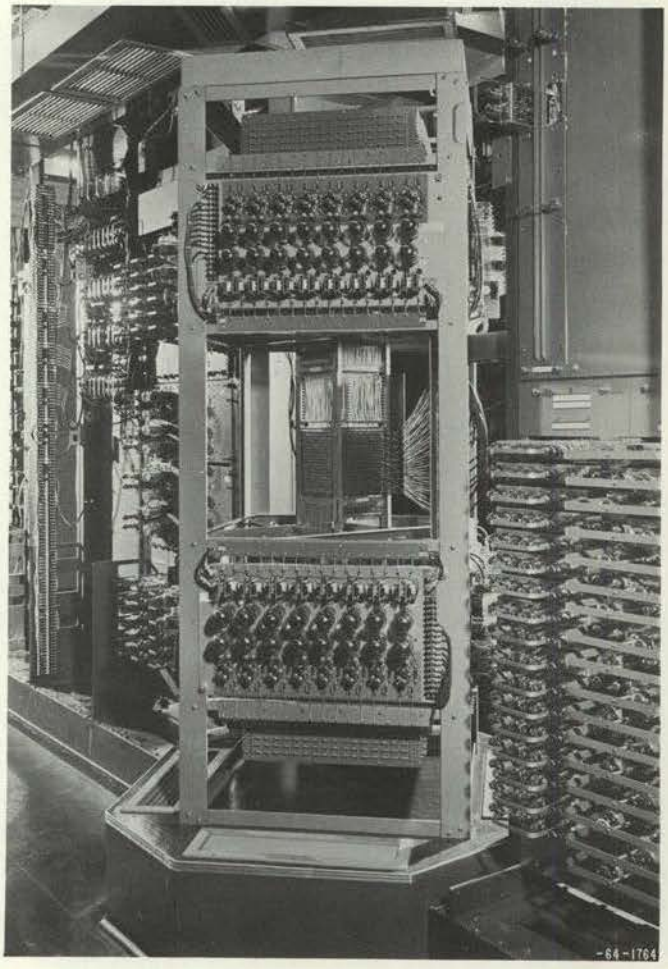


Fig. 64-7. Whirlwind I, additional 4096 registers for core memory.

channels. As the new plug-in units arrive, the Bath channel will be restored and the second South Truro channel completed.

Several logical design changes and circuit design modifications were introduced while testing the South Truro channel, resulting in better margins for this channel than were found on the Bath channels. The Bath channels will be modified to incorporate the improved circuits.

b. Core Memory Addition

The addition of 4096 registers of core memory to the original 2048 was completed (Fig.64-7). By the end of November, the new memory had operated for 420 hours without error.

c. Other Changes

The logic problems involved in the proposed change to the magnetic drum interlace to reduce the block transfer time are being studied.

The display system is being modified and changes for accomplishing the following have been completed:

(1) Providing reduced-size characters for expanded situation displays (this requires a new control and a new numerical waveform generator)

(2) Increasing the number of display gates available for future CCS testing.

The TBS facilities have been relocated to provide space for a visitor's room. The equipment will include four situation display scopes and four DID display scopes connected to permit selective duplication of any display in the direction center. In addition, all CCS radio traffic will be selectively available.

The ESS method of ground-to-air radio communications is being installed at the Intercept Directors' positions.

Group 22 requested an investigation of the possible use of automatic output and input teletype operation at WWI for future CCS tests. As a result of the investigation, a proposal was drafted for an output teletype installation at WWI to operate a teletype line connected in multipoint fashion to three receive-only teletypewriters located at the Hanscom Air Force Base. Authorization to proceed was received late in November.

2. WWI Computer Operation

WWI operation and reliability for this quarter, measured over 2-week periods, are as follows:

	Total
Scheduled Computer Hours	2241.7
Interrupting Incidents	119.
Hours Lost	39.7
Per cent Good Time	98.2
Mean Time Between Failures (in hours)	21.3

L. L. Holmes
D. F. Allen
E. K. Gates
L. D. Healy
D. A. Morrison
P. J. Murphy
L. H. Norcott
A. J. Rowe

UNCLASSIFIED

UNCLASSIFIED

VACUUM TUBES

GROUP 65

Youtz, P., Leader

Clough, T. F.
Palermo, J. S.
Tandy, P. C.
Twicken, S.

UNCLASSIFIED

V. VACUUM TUBES
GROUP 65

A. SUMMARY

Stromberg-Carlson produced 213 acceptable Charactrons at a production efficiency of 76.6 per cent. The number of tubes available exceeded the demand by IBM and Hazeltine. Low cathode emission appears to be the limiting factor in Charactron life according to the results of life test programs at Stromberg-Carlson and MIT. If, when the AN/FSQ-7 becomes completely operational, greater demands are made on the cathode for more light output, the average tube life will be further shortened. The 74 Charactrons at XD-1 and XD-2 display consoles had accumulated an average life of 5641 hours by the end of this quarter. The cathode study program now being conducted by Group 65 indicates that improved processing techniques will probably increase the life of oxide coated cathodes. Bariated-nickel cathodes have been produced which were consistent within lots and showed promise of long life. Two more 19-inch Charactrons with bariated nickel cathodes were put on life test. The possibility that easier alignment of Charactron deflection systems will result from the use of an electrostatic lens instead of a magnetic convergence coil is being investigated.

Ninety-four Typotrons in the XD-1 and XD-2 display consoles had accumulated an average life of 5276 hours as of 30 November 1956. Gassy tubes accounted for the majority of the failures. A dissection and analysis program showed that this gassy condition was caused by arcing within the tube. It was recommended that the operating conditions and methods of voltage application in the display consoles be investigated. Hughes has been asked to study possible design changes to make the Typotron less susceptible to arcing.

A variety of electroluminescent surfaces were prepared for the solid state studies of Group 24. Several experimental tubes were also designed and constructed for the group to investigate the electron beam triggering of electroluminescent storage cells.

General Electric is still investigating the problem of an increase in microphonics in the low-power twin triode noted during recent production runs. Raytheon has had production problems with the 6414 in simultaneously centering both the plate current and the amplification factor. They are still working on this problem.

Sylvania halted production temporarily on the dual-control pentode 6888 because of excessive inventories. Sylvania was asked to propose a specification control on the plate current at a +25-volt grid drive to complement the present plate current control specification at +10-volt drive. Analysis of AN/FSQ-7 circuit requirements has indicated the necessity of the additional plate current control to limit tube design variations and to insure complete interchangeability.

Although Tung-Sol intends to continue a small improvement program on the DT-438 with its own funds they have been asked to concentrate their efforts on the production of commercial 5998 tubes for AN/FSQ-7. The availability of these tubes for AN/FSQ-7 has always been a problem and continual surveillance by the IBM-MIT tube group has been required to maintain satisfactory levels of quantity and quality. Cathode peeling after 500 hours of life has been the major production problem on the 5998 at Chatham Electronics.

P. Youtz

GROUP 65

B. DISPLAY

1. Charactron

The factors affecting the life and performance of the 19-inch cathode-ray tube meeting the AN/FSQ-7 situation display requirements continued to be evaluated and estimated.

a. Production

The demand for acceptable Charactrons at IBM and Hazeltine has been less than the production by Stromberg-Carlson. Stromberg-Carlson again cut back its production this quarter and completed 213 acceptable tubes at a production efficiency of 76.6 per cent – a slight improvement in efficiency over last quarter. Production efficiency was depressed by an epidemic of failures due to grid emission but the problem was under control before the end of the quarter. The reduced demand for the Charactron, however, threatens economical and continuous production.

b. Life-Test Program

Stromberg-Carlson has been operating a 12-position life-test rack with production Charactrons made during the Fall of 1955. Test results as of 30 November 1956 are summarized below:

Life-Test Hours Before Failure	Reason for Failure		
	Low Emission	High Voltage Leakage	Grid-Cathode Leakage
124			X
505		X	
586		X	
2079	X		
3091	X		
4172			
4798	X		
5236			
5452	X		
5577	X		
6150	X		
6590	X		
6741			
6776			
6798			
Totals	7	2	1

No. Tubes on Test	15
Failures	10
Average Hours to Failure	4820
Operating satisfactorily as of 30 November 1956	5

Leakage is the greatest short-life problem and can frequently be picked up at initial test. Corrective action has been taken in the manufacturing process to minimize this occurrence. The two early life failures for cathode emission had a low matrix current on initial tests. A correlation curve plotting matrix current at 500 hours vs data at 4000 hours indicated that the life of a cathode can be inferred from the initial and the 500-hour matrix current. More data must be gathered on this subject before firm conclusions can be drawn.

Seven Stromberg-Carlson Charactrons fabricated prior to the Fall of 1955 have been on the MIT life-test racks with five similar tubes made at MIT. There were three failures in each group, all of which were due to low emission after an average of 4464 hours. One MIT tube not included in the average ran for 14,577 hours before failure. As of 30 November 1956 four Stromberg-Carlson tubes were still operating after an average of 8092 hours. Of the two MIT tubes still on life test one (bariated-nickel cathode) has accumulated 4328 hours and the other 13,767 hours.

The display consoles in XD-1, XD-2, and the IBM test cells have been providing operational history of the early production Charactrons. Performance requirements on the Charactrons have not been as sustained as they might be in the future when XD-1 is completely operational. Furthermore, any demand for a brighter display with a resulting increase in beam current would shorten the average life of the tubes. Under present requirements only three Charactrons were rejected this quarter from consoles. All three were rejected for low emission after an average operating life of 4571 hours. The 74 Charactrons remaining in the display consoles had accumulated on 30 November 1956 an average life of 5641 hours distributed as shown in Fig. 65-1.

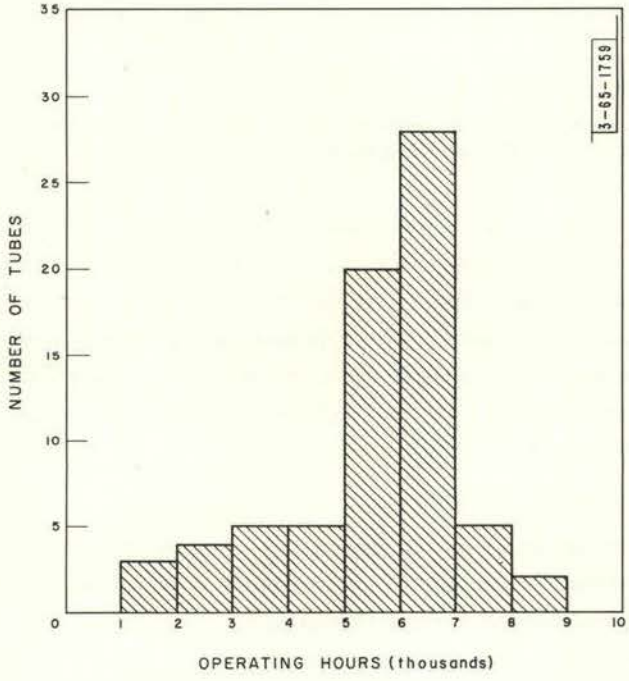


Fig. 65-1. Distribution of life of 74 Charactron tubes remaining in operating display consoles as of 30 November 1956.

Investigations are continuing to develop techniques to improve the life of Charactron cathodes.

Fourteen Charactrons with an average life of 3809 hours in the XD-1 display consoles began to exhibit a phenomenon in which they focused to a line instead of a point. This problem, which had been observed on one of the MIT life-test tubes, became increasingly serious with age. Stromberg-Carlson has been alerted and they will conduct an investigation to determine the cause and correction of this phenomenon.

c. Oxide-Cathode Studies

A series of life-test tubes for oxide-coated studies was constructed with different activation schedules and cathode materials. Thirty-nine tubes passed acceptance specifications and were put on life tacks. Fifteen tubes with an average life of 6439 hours as of 30 November 1956 continued to meet cathode specifications similar to IBM acceptance test specifications for the Charactron.

The program indicates that some of the current processing techniques for oxide-coated cathodes are not satisfactory for long-life tubes and that a more advantageous method should be found.

At the 1956 Fall Tube Techniques Conference in New York City and at the PGED Fall Symposium in Washington, D.C., some new surface processing techniques were revealed. It was claimed that the application of these techniques to tube construction would lead to an improvement in cathode life. These techniques will be investigated and related to the Charactron program.

d. Bariated-Nickel Program

Thirty-five bariated-nickel cathode test tubes were processed this quarter. Their life performance was considerably better than tubes processed any previous quarter for two reasons:

(1) Variations in the tube types were limited to those employing techniques that had produced successful tubes in the past.

(2) More tubes of each type were made in each lot. The tubes were quite consistent within lots and stabilized at the given bias voltage early in life.

The four failures this quarter were due to cathode-grid leakage which has been the predominant cause of failure during this whole development. The problem has been alleviated by increasing the cathode-to-grid aperture-disc spacing to .007" compared to the previous spacing of .005".

Two more 19-inch Charactrons with bariated-nickel cathodes were made this quarter for life test under conditions similar to those for commercial Charactrons with oxide cathodes. Further development work on this program will be dictated by the data to be accumulated on the three 19-inch tubes completed to date.

e. Electron-Optics Studies

One tube with a sliding target was designed and constructed to investigate the possibility of an electrostatic lens instead of a magnetic convergence coil in the Charactron and Typotron electron optics. This tube was turned over to Group 63 for evaluation. Also, Stromberg-Carlson and Hughes Aircraft were encouraged to work along similar lines. Two focus-study tubes were designed and constructed to evaluate the new Stromberg-Carlson convergence coil, C18A10, which was designed to eliminate the mechanical alignment difficulties of the old magnetic convergence

coil and to compensate for misalignment by electronic circuitry. The focus-study tubes were in 2-inch cylinders with a phosphor screen at the same distance from the cathode as the matrix of the 19-inch display tube and the 5-inch projection display tube.

2. Typotron

The factors affecting the long-term reliability of storage tubes for data display in AN/FSQ-7 continued to be studied. No failures were reported this quarter in the seventeen early production tubes which continued on the life-test racks of Group 65. The tubes were tested periodically to the IBM purchase acceptance test specifications, which eight of these tubes continued to meet. These eight tubes have accumulated the following history:

Number of Tubes	Number of Hours
3	7770
2	7855
2	13651
1	14377

Since no end of life specifications have been designated, Typotrons have been kept on life test and in display consoles as they were operable without complaints from the operating personnel. The complete history of the 17 life-test tubes is:

Number of Tubes	Number of Hours
6	7770
4	7855
2	13651
5	14377

No other organization has yet initiated a life-test program. Hazeltine has a life-test rack under construction which should be operable next quarter for sample testing of the current production Typotrons.

The display consoles in XD-1, XD-2, and the IBM test cells have continued to give operational history of the later production tubes. When there are more stringent operational requirements on the tubes, the operators may insist on higher performance from the tubes and reject them earlier in life. This quarter 12 Typotrons were rejected from the display consoles for the reasons indicated in the table below which includes the operating hours before failure occurred:

Number of Tubes	Hours to Failure	Reason for Failure
1	47	gassy
1	152	gassy
1	539	gassy
1	751	leakage
1	999	gassy
1	5155	open writing gun filament
1	5162	gassy
1	5202	gassy
1	5566	open writing gun filament
1	5584	grid-to-cathode short in write gun
1	5690	grid-to-cathode short in write gun
1	7853	grid-to-cathode leakage in flood gun

GROUP 65

The 94 Typotrons in the display consoles had accumulated on 30 November 1956 an average life of 5276 hours with a distribution of life-test hours as shown in Fig. 65-2.

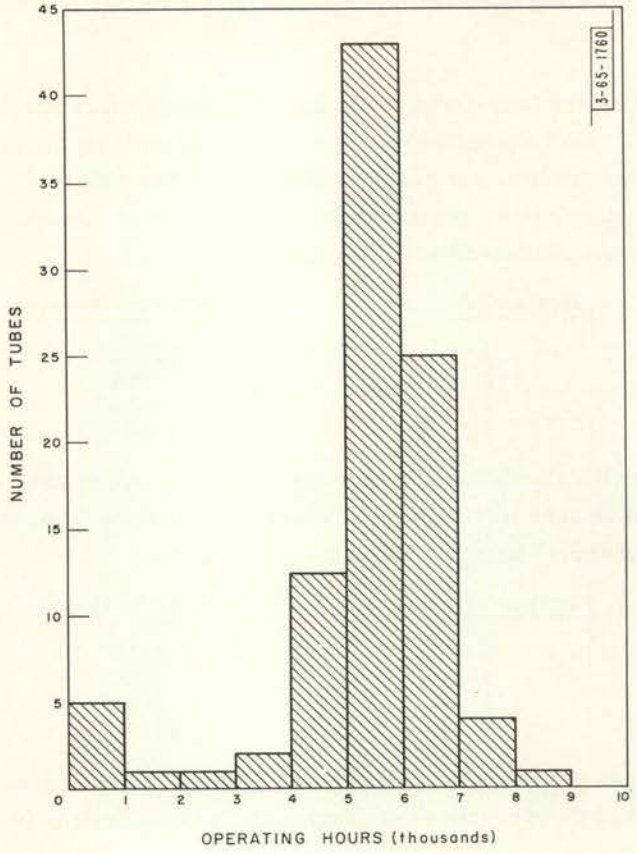


Fig. 65-2. Distribution of life of 94 Typotron tubes remaining in operating display consoles as of 30 November 1956.

As the Typotrons accumulate operating hours in the display consoles, the percentage of failures for gassy tubes decreases. It is only 50 per cent this quarter and is decreasing each month. Over 50 per cent of the Typotrons rejected from consoles in previous quarters have been gassy. IBM, Hughes, Hazeltine, and MIT set up a joint two-day dissection and analysis program at MIT to determine the causes of these failures. There was no definite evidence of leaks found during the dissection program. However, there was evidence of arcing between the dag coating in the vicinity of the viewing screen lead and the can which supports the ion repeller mesh. This arcing released gas which made the tubes inoperable. It was not apparent what had initiated the arcing which was intensive enough to discolor the can. There was also arcing between the A_3 button and the can. None of the 35 Typotrons that have been on the MIT life racks has failed because of gas. It is possible that some operating condition in the console might aggravate this arcing. It was recommended that a careful survey be made of the operating conditions and methods of voltage application in the display console. Also, it was suggested to Hughes that they study possible design changes to make the Typotron less susceptible to arcing. The second

most prevalent cause for removal of Typotrons from display consoles was interelectrode insulation leakage. In some cases it was loose particles of the collector mesh and in others the grid had picked up material from the cathode during operation.

No information has been released on production rate or efficiency for Typotrons at Hughes except that the production of acceptable tubes has been greater than the demand. In fact, the demand has been so low that it jeopardizes the continuous and economical production of the tubes.

3. Electroluminescent Storage

The solid-state display studies of Group 24 continued to receive considerable technical support from Group 65 with the design and construction of special tubes and preparation of special surfaces. A tube to be continuously pumped on the Group 24 vacuum system and to be used to observe the effect of electron beam excitation with a CdS photoconductor and a ZnS electroluminescent sandwich was designed and constructed. This was a demountable tube with a ground glass joint so that the target assembly could be changed without destroying the glass seal to the vacuum system and without removing the gun from the envelope. This tube was turned over to Group 24 for activation of the cathode and evaluation of the sandwich under electron bombardment.

A specially processed 2-inch sealed off tube was designed and constructed to investigate the electron beam triggering of electroluminescent storage cells. This tube was excessively gettered with barium getter and had an activated carbon cold trap to compensate for the elimination of the regular high temperature baking which would have destroyed the photoconductivity of the CdS surface.

C. RECEIVER TUBE RESEARCH AND ENGINEERING

1. Low-Power Twin-Triode (Type 0528/6414)

a. General Electric Company

The failure rate of this type in XD-1 has continued to be comfortably small. Except for the number of open-heater failures caused by defective filament transformers, the only major defect has been the microphonic "noise," reported in the QPR dated 15 September 1956. The 6414 tube was not designed to be particularly low in microphonics because of compromises which would have been necessary in the basic design criteria. Nevertheless, the level of microphonics has been getting higher than it was originally. This fact aggravates the situation in which the flip-flop has proved to be more sensitive to noise than predicted by the design. For particularly low-noise applications, e.g., the first stage of the memory sense amplifier, a different tube type (6072) is used.

GE is continuing its efforts to solve the complex microphonics problem. The clearance of the cathode sleeve in its mica hole could be reduced by reducing the diameter of the mica hole. However, this would introduce the possibility of cathode bowing during high temperature exhaust because of restricted expansion of the sleeve. Such bowing would actually increase the microphonic output and the probability of shorts. To date, no 0528 failure in XD-1 has been definitely determined to have an interelectrode short.

b. Raytheon Manufacturing Company

Raytheon has not yet been able to solve the production problem of simultaneously centering both plate currents and the amplification factor. It has been proposed by Group 65 that some extraneous material on the grid wires alters the contact potential sufficiently to raise the Class A plate current above bogie. Alterations in geometry to overcome this problem would be ineffective since they would throw the amplification factor out of specifications. Raytheon has not conceded that material on the grid is the source of the difficulty and have continued their studies of design variations.

Raytheon also has been experiencing some difficulties with non-uniformity of grid geometry, cathode bowing, and microphonics. Although no one of these difficulties represents an extremely pressing system problem, in the aggregate they contribute to a fairly low yield at Raytheon and a reduction in the over-all quality of the product accepted for AN/FSQ-7.

2. Dual-Control Gate Pentode (Type SR-1782A/6888)

a. Sylvania Electric Products, Inc.

The last of the special-design 6888's have been received from Sylvania and analyzed. The results looked so promising that the manufacture of additional design variations was dismissed. The last samples had plate currents at +10 and +25 volts drive sufficiently high for our purpose.

Tube production at Sylvania has been halted temporarily due to a large inventory of finished tubes. Arrangements have been made with Sylvania to produce 1,000 tubes of the special design over a period of four to six weeks in order to determine the statistical variation within the lot so that limits at +25 volts grid drive can be added to the specification. These tubes will be produced during the next quarter when production is resumed.

Although the number of failures of this tube type in XD-1 has been fairly low, a high percentage of them has been due to faulty welds. This information, photographs, and tubes have been given to Sylvania for appropriate action.

b. Bendix Aviation Corporation, Red Bank Division

When the need for second sources of the basic AN/FSQ-7 tubes was recognized, one requirement was that the second source begin with design and processing as identical as possible to those of the first source. In the case of the type 6888, this required that Bendix use a special nickel grid #1 wire in whose control and processing Sylvania had accumulated many years of experience but with which Bendix was unfamiliar. Bendix had desired to use molybdenum wire (also gold-plated) which is quite common in the tube industry but which Sylvania had not used for this particular tube type.

Bendix has had persistent difficulty in controlling in production the minor diameter of the #1 grid using the nickel wire. They have run many tests using molybdenum wire which have demonstrated a much greater ability on their part to control this wire. Therefore, the IBM-MIT Tube Group has given Bendix permission to switch over to the gold-plated molybdenum grid wire in production. This changeover should take place early in the next quarter.

Bendix has been kept appraised of the results of the dimensional analysis program conducted with Sylvania and has been asked to make some tubes of the design of which Sylvania is to make

about 1,000 samples. The desired specification control on plate current at +25 volts grid drive which will apply to both sources is not statistically feasible with the present design.

3. High-Power Twin-Triode (5998/DT-438)

a. Tung-Sol Electric Company

Following the termination in July 1956 of financial support by IBM of the DT-438 (improved 5998 program), Tung-Sol supported this program itself until November 1956. At that time, primary activity on the DT-438 was terminated by mutual consent and the emphasis was shifted to building standard 5998's under improved conditions.

Although the present quality of the 5998 is not as high as desired, it is usable for AN/FSQ-7 provided that no major catastrophies occur. During the past two years the type 5998 has required continual surveillance to insure its utility and availability for AN/FSQ-7. Tung-Sol is supporting its own smaller effort on the DT-438 which involves a new approach aimed toward a redesign which would permit wider electrode spacings.

b. Chatham Electronics

Production by this company, which was chosen as a second source for the type 5998, is now stalled as a result of cathode peeling during life. Although the tubes marginally meet the commerical life test requirements of 500 hours, peeling sets in at less than 1000 hours and the tubes are not usable for AN/FSQ-7. An intensive effort at Chatham is reported by them to have remedied the difficulty; we have not yet examined these tubes.

A subject of considerable negotiation between IBM and Chatham is the fate of a large number of tubes which met the 500-hour life test requirement but are not usable for AN/FSQ-7 because of peeling during later life. Chatham has adopted the point of view that their continuance of manufacture of this type depends on the outcome of the negotiations. We are left, therefore, in the position that neither of the two sources of 5998's is steadily supplying quality tubes for AN/FSQ-7 without recurring difficulties and surveillance.

c. Bendix Aviation Corporation, Red Bank Division

In an effort to find a permanent solution to the shorts problem in the 5998, Bendix was given a study contract to determine the feasibility of reproducing the characteristics of the 5998 in a tube with wider electrode spacings. This study has been progressing along two paths simultaneously: (1) replacing each of the two high-transconductance sections of the 5998 with two low-transconductance sections in parallel to create four triode sections in each envelope; and (2) increasing the cathode area by using a wider and longer cathode which would give the same plate current and transconductance as the present tube but with wider electrode spacings. Bendix plans to have a few hand-made samples of both designs with a final report in March 1957. Should such a redesign turn out to be feasible, it has not yet been decided what effect this will have on the present sources of the 5998. There undoubtedly cannot be three sources of this type for economic reasons; the number of tubes of this type used for each AN/FSQ-7 system is barely sufficient for two sources operating at an absolute minimum production level.

P. Youtz

SAGE DC AND CC SITES

GROUP 66

Morriss, B.E., Leader

Bragar, P.
Brock, L.T.
Croke, J.
Hedison, H.
Holden, W.
Ippolito, V.
Johnson, F.B.
Linehan, L.H.
Manning, F.F.
Mayer, R.P.
McVicar, K.E.
Roberts, A.J.
Sergio, L.S.
Shorey, R.R.
Shortell, A.
Smiley, E.L.
Thompson, S.L.

VI. SAGE DC AND CC SITES
GROUP 66

A. SUMMARY

Some 30 people per month have been hired by the RAND Corporation during September, October, and November. A training course has been set up to train these new people in the operations of the DCA computer programs. Dynamic flow diagrams were designed which clearly show every step of a program and from which an understanding of its operation can be easily grasped.

The utility system programs were installed on the duplexed AN/FSQ-7 at McGuire Air Force Base and on the XD-2 and on two duplexed AN/FSQ-7's at Kingston by the end of the quarter. Some programs of Package A of the DCA program were also initially checked out at McGuire and it is expected that test instrumentation will be completed and available for the field test teams when they arrive in January.

B. E. Morriss
K. E. McVicar

B. COMPUTER PROGRAM INSTALLATION AT SAGE SITES

The intensive campaign of the RAND Corporation to hire the people required to install the computer programs at SAGE sites has continued throughout September, October, and November. An average of approximately 30 people per month has been hired since September. A 12-week course has been established to train the new RAND people and acquaint them with the background and operations of the computer programs. The course consists of a series of lectures covering the SAGE operational specifications, the subprograms that make up the total SAGE DCA program, and computer operation during checkout. A method of representing a computer program has been devised by which a clear and detailed understanding of its operation can be grasped easily. The dynamic flow diagrams thus developed clearly show every step of the program, all references to individual stored parameters and variables, and all modifications to instructions, references to subroutines, etc.

1. Dynamic Flow Diagrams

The drawing of dynamic flow diagrams has provided valuable, on-the-job training to the new people in the group; the diagrams will eventually describe all subprograms in the entire DCA program.

The design of the diagrams was based on the techniques used by the people who originally wrote the computer programs. The following principles, which have proved valuable for designing and explaining computer logic, were also used for designing dynamic flow diagrams:

(a) A concept, once expressed, should not be repeated except for emphasis or ease of reference.

(b) Each repetition should find the concept in its original form.

(c) The physical relationships on a drawing should be similar to the logical relationships in the thing being drawn.

GROUP 66

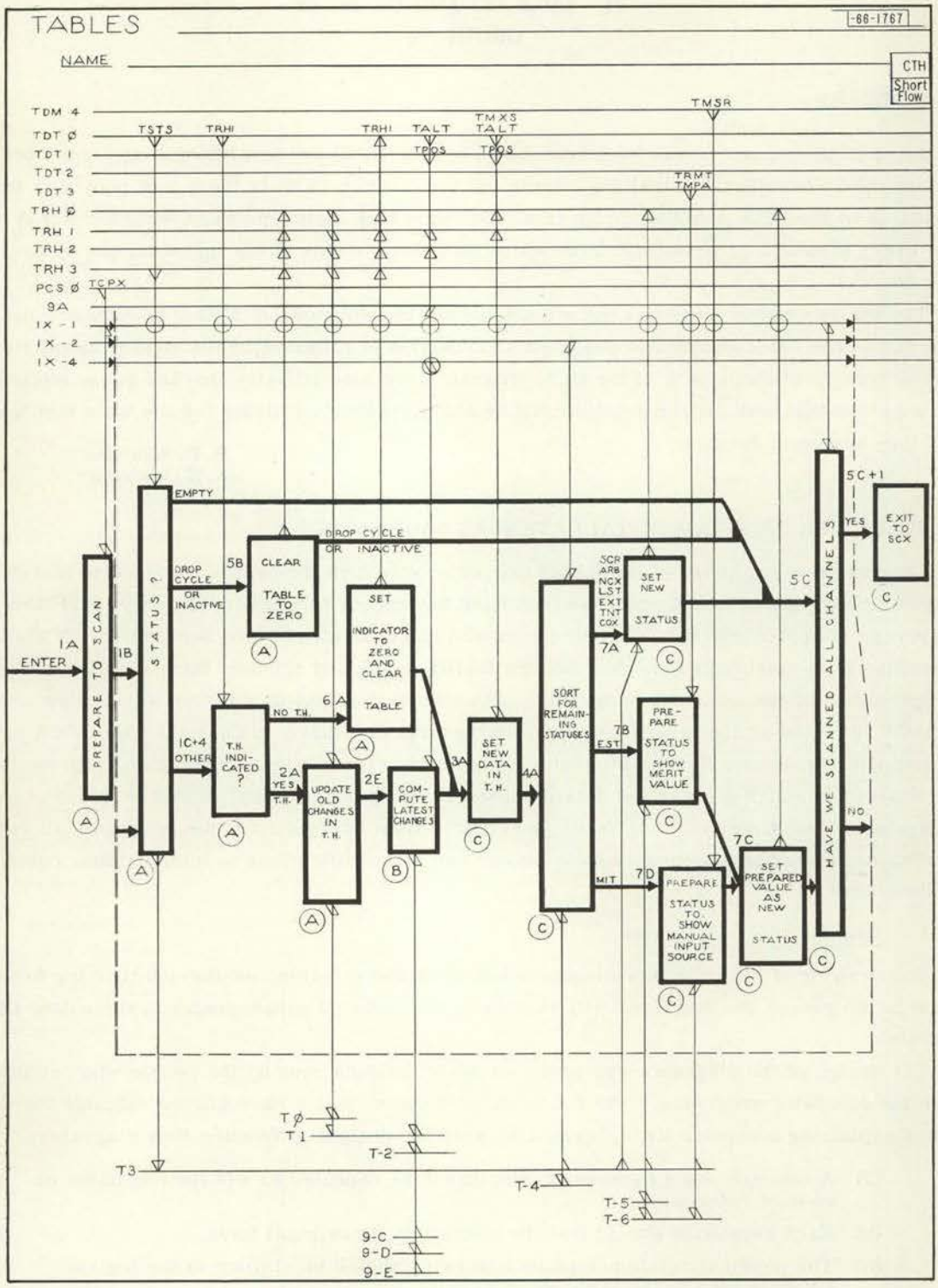


Fig. 66-1. Short flow diagram.

Therefore,

(d) A large system should be expressed in a carefully designed, all-inclusive concept.

(e) All elaborations of detail should be compatible with the original form of the concept.

(f) The concept should include at least one dimension of equipment (laid out in space) and one dimension of time.

(g) Elements which repeat in one or the other of these dimensions should not be shown more than once, but their repetition should be indicated.

(h) All elements should be shown interconnected because, in a complex system, the interrelationships of all equipment and processes are important to the whole.

Two types of diagrams will be drawn for each of the nearly 100 subprograms of the total DCA program: A short-flow diagram will show all references in a particular subprogram on one page; details of the references will be expanded in detailed flow diagrams on succeeding pages. Figs. 66-1 and 66-2 are examples of these two types of dynamic flow diagrams.

2. Training

In addition to the 12-week course in SAGE System programming and operational concepts being conducted at the RAND Buildings in Lexington, training is provided at Kingston for computer operators and test facility and utility system specialists. By the end of the quarter the utility system of computer programs was installed and checked out on XD-2 and two AN/FSQ-7's that were ready for shipment to direction centers.

3. McGuire Installation

Members of the test facility operations section were on site at McGuire Air Force Base by mid-November to install the test instrumentation programs for checking out the DCA program and to install the utility system programs on the duplexed AN/FSQ-7 there. By the end of the quarter, the utility system was installed and some programs of Package A of the DCA program were initially checked out.

P. Bragar
L. T. Brock
J. Croke
H. Hedison
W. Holden
V. Ippolito
F. B. Johnson
L. H. Linehan
F. F. Manning
R. P. Mayer
A. J. Roberts
L. S. Sergio
R. R. Shorey
A. Shortell
E. L. Smiley
S. L. Thompson

GROUP 66

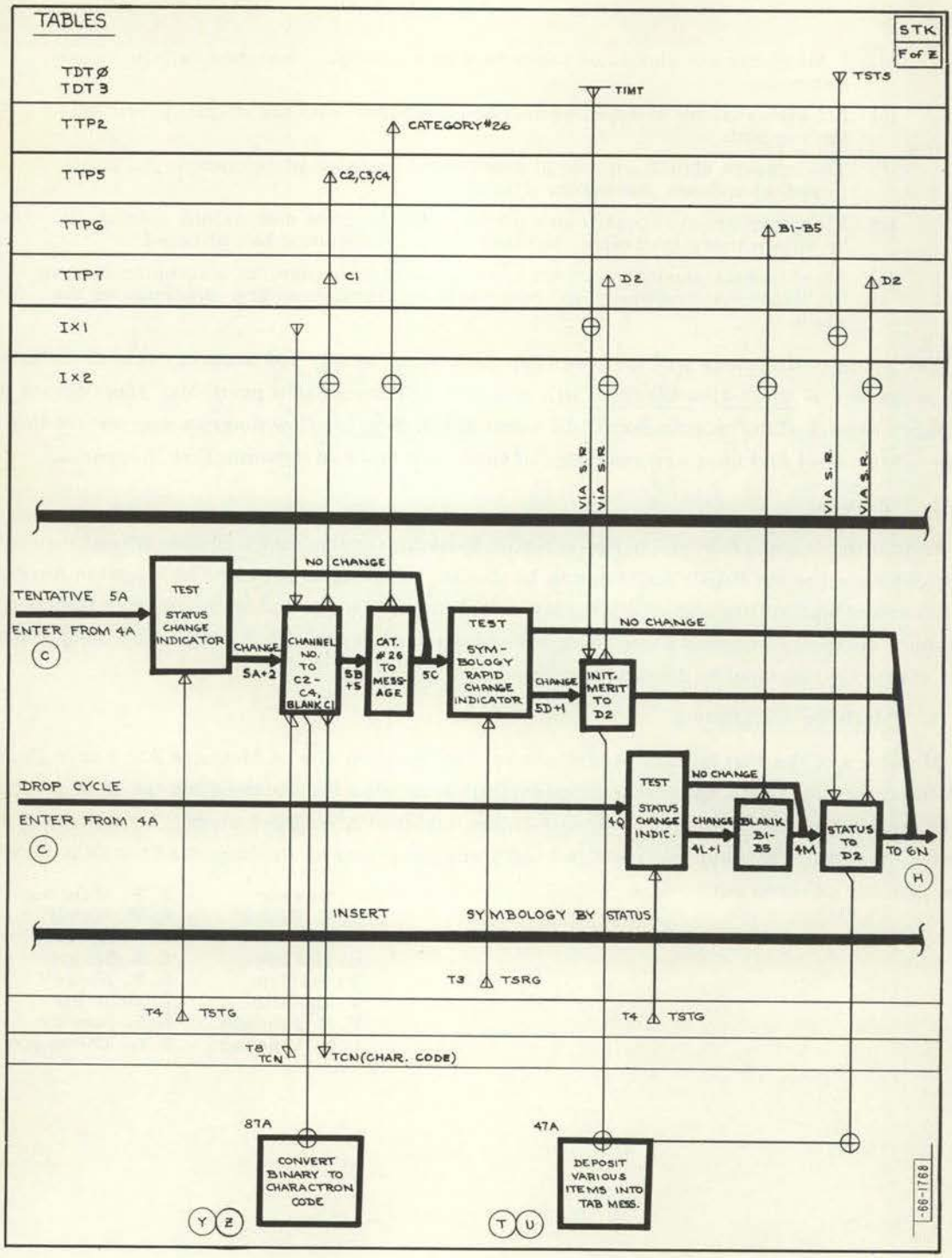


Fig. 66-2. Detailed flow diagram.

PROGRAM PRODUCTION

GROUP 67

Arnow, J. A., Leader

Arden, Marguerite
Bagley, P. R.
Bailey, D. L.
Benington, H. D.
Bensley, E. H.
Briscoe, H. W.
Burrows, J. H.
Byrne, W. J.
Carson, J. J.
Chandler, A. R.
Char, Beverly
Clapp, Elizabeth
Collins, L. B.
Coyne, J. D.
Douglas, E.
Ferguson, Mary E.
Fletcher, J.
Frachtman, H. E.
Ginsburg, A. R.
Gochman, H.
Hager, L. S.
Hazel, Inez
Hills, A. M.
Kelley, Frances T.
Kirshner, H. J.
Latimer, D. P.
Lundberg, E. D.
Marnie, G.
McEvoy, Eleanor J.
Newhall, H., Jr.
Ornstein, S.
Patton, R. L.
Pendergraft, E.
Rising, H. K.
Rupp, A.
Shoolman, A. R.
Stone, Judith H.
Thomas, L. M.
Vance P. R.
Wilson, L. D.
Zraket, C. A.

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VII. PROGRAM PRODUCTION
GROUP 67

A. SUMMARY

The computer program for the active computer of a SAGE direction center (the DCA program) has been further broken down into four "packages" of subprograms that contribute to the functional build-up of the whole program. The first of these packages, Package A, has been completely coded, parameter tested, assembly tested, and adapted to ESS, and at the end of the quarter was ready to be turned over to Group 64 for operation during the first ESS shakedown test, scheduled for 3 December.

Package B is scheduled for release to Group 64 on 1 March 1957, and Packages C and D, representing the complete simplexed DCA program, are scheduled for release on 1 June 1957.

These packages will, at the same time, be released to Group 66 for installation at the McGuire direction center.

Improvements to and simplification of the DCA program have so far resulted in a net saving of 14,000 registers of drum storage, thereby decreasing parameter checkout requirements, reducing demands on XD-1 computer time, and easing the shortage of drum storage. The implementing of the program improvements only slightly affected intermediate dates in the over-all program production schedule.

A routine procedure, to be as nearly automatic as possible, is being designed for adapting the DCA program to all SAGE direction centers. The possibility of a special computer program for accomplishing adaptation is being investigated.

J. A. Arnow, Group Leader
H. D. Benington, Assoc. Group Leader
C. A. Zraket, Assoc. Group Leader

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B. DCA COMPUTER PROGRAM

The DCA computer program has been further broken down into four "packages" of subprograms, which correspond to four operational segments of the whole program, as follows:

Package A:

- radar inputs
- automatic tracking
- manual track initiation
- operational recording
- simulation
- (Digital displays and some simulation situation displays are not in Pkg. A)

Package B:

- Package A, plus:
- identification
- height finding

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automatic track detection
track monitoring
manual inputs
(No digital displays)

Package C:

Packages A and B, plus digital displays
(Only those digital displays that are a part of operational functions in packages A and B are actually displayed)

Package D:

Packages A, B, and C, plus:
manual crosstelling
raid forming
antiaircraft weapons assignment
interception

At the end of this quarter, Package A had been adapted to ESS, had been assembly tested, and was ready for Group 64's ESS shakedown testing which is scheduled to begin on 3 December. There are some minor restrictions within Package A, since not all parts of the functions that make it up are contained within it. E.g., an identification feature is not included and, therefore, tracks are limited to a pending identification, and certain identity-sensitive features of automatic tracking are unavailable.

Package B is scheduled for release to Group 64 on 1 March 1957, and Packages C and D are scheduled for release on 1 June 1957. An attempt will be made to have the digital display programs ready sooner, however.

1. Program Preparation

Coding has been completed on all DCA subprograms except those involved in weapons situation displays, automatic crosstelling, forwardtelling, and safe-data maintenance (duplex-standby).

A committee studying possible program improvements issued its first recommendations for simplifying the DCA program and thus reduce its storage requirements.* It was found that a few programs could be completely eliminated, thereby decreasing parameter checkout requirements, reducing demands on XD-1 time, and easing the shortage of drum storage. Programs involved in the following functions were affected by the improvement study:

(a) track monitoring
(b) height finding
(c) identification
(d) digital displays

Improvements resulted in a net saving of about 14,000 registers of drum storage. Parameter checking of these programs was delayed only slightly. Improvements to programs that had

*J.J. Carson and A.R. Shoolman, "Program Improvement Procedures," MIT Lincoln Laboratory Report 6M-4784 (15 November 1956).

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already been released for assembly testing were effected by the people in that section. However, in one program (air surveillance situation displays) the changes were so extensive that it had to be recoded and re-released.

2. Assembly Testing

In addition to completion of the assembly testing of Package A, the method of recording assembly-test outputs has been improved. The original output system provided printed test information in its crudest form, i.e., an image of the information recorded on magnetic tape, including much data not pertinent to the test. Modifications have been made which provide some simple editing of the printed information, such as: elimination of useless information (check sums, data on inactive tracks, bookkeeping information); and tabulation. Further improvements being made will provide partial interpretation of recorded data, e.g., direct printout of track position in miles; track identities such as P (pending), F (friendly), H (hostile), U (unknown), K (Faker).

Problems experienced during assembly testing were, as expected, mostly concerned with communication between programs, rather than with the programs themselves. The radar-inputs programs operated correctly with both live data from drums and simulated data from tapes. They also correctly produced radar data by means of the real-time data-generation program.

Correct operation of the DCA recording program with programs of Package A was also verified. The DCA recording programs were run during assembly tests and their outputs were compared with those obtained from the assembly-test recording system.

Corrections that had to be made to the Package A programs as a result of errors discovered during assembly testing were minor, and were discovered and made early in the test.

3. Adaptation

Packages A and B of the DCA program were adapted to ESS by the end of the quarter, and methods had been specified for adapting the weapons programs, some of the digital-display programs, and all but a few of the switch programs.

Design and coding of the fixed geography to be displayed in the ESS direction center was also completed. Fixed geography provides for a display of coastline, subsector boundaries, ADIZ boundaries, radar sites, air bases, radio sites, georef, and other information pertinent to the operational air defense problem.

The need has been recognized for a method by which the DCA program can be adapted to all SAGE subsectors on a production basis. All information, all decisions, and all processes required to produce an adapted DCA program must be specified in detail, and provision must be made for changes to both the operating requirements of the system and the design of the computer program. A study was undertaken to design such a procedure and an "Adaptation Data-Processing Manual" was written. A series of nine documents will eventually describe the processing of adaptation data from start to finish, as follows:

(a) External Data Guide
(b) External Data Form
(c) Data Analysis Manual

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(d) Analysis Implementation Manual
(e) Subsector Data Guide
(f) Subsector Data Form
(g) Data Calculation Manual
(h) Program Data Form
(i) Coding Manual

The possibility of adapting a computer program by means of a special program has also been studied and initial design of and specifications for such a program have been completed. It is estimated that 90 per cent of the work of adaptation can be done by programs.

4. Mathematical Parameters

There are many constants in the DCA Master Program which may be varied to provide for changes in standard operating procedures, and the specification of these constants involves many operational considerations. They also affect certain design features of the program itself. All such items in Package A have been specified and defined, together with the considerations upon which they are based, the range over which they may be varied, and the programs, tables, items, and operational requirements to which they are related. This information will be included in the coding specifications.

5. Equipment Coordination

a. AN/FSQ-7

Because the AN/FSQ-7 computer that will be used in SAGE direction centers differs in some respects from its experimental prototype, XD-1, which will be used in ESS, some subprograms of the DCA program must be modified. The program modifications that will be required have been specified,* together with suggested alternate coding. Group 66 will use this information while preparing the DCA program for operation in the McGuire direction center.

b. Equipment

Many of the decisions made in the adaptation process also affect the manner in which equipment is installed in a subsector. Such items as site priority, input-output channel assignments, switch coding, and track monitor assignment areas are being specified for the use of the organizations responsible for equipment installation in the McGuire direction center.

6. Operational and Mathematical Specifications

The operational and mathematical specifications, as a result of the program improvement studies, must also be modified so that they will properly describe the functions now provided by the computer programs. Writing of the necessary revisions has begun.

D. L. Bailey	J. D. Coyne	H. Kirshner
H. Briscoe	H. Frachtman	D. Latimer
J. J. Carson	A. Ginsberg	G. Marnie
A. R. Chandler	L. Hager	R. L. Patton
Elizabeth Clapp	Inez Hazel	A. Rupp
L. B. Collins	Frances Kelley	L. Thomas

*G. Marnie, "Adaptation to AN/FSQ-7 of the Initial Direction Center Active (DCA) Program," MIT Lincoln Laboratory Report 6M-4846 (to be published).

C. UTILITY SYSTEM

The last three of a total of thirteen programs of the Utility System* were completed and put into operation. Most of this quarter was spent correcting and refining the system, preparing test specifications and test decks of cards, reviewing proposed changes and incorporating them in the system, and bringing up to date the documents pertaining to the system (listings, flow diagrams, specifications, etc.).

A course, designed to give computer operators the background for a working knowledge of the utility system, was concluded in November. It was also intended to provide a better understanding of computer operations in general.

P. R. Vance
Marguerite Arden
P. R. Bagley
J. H. Burrows
Beverly Char
Eleanor McEvoy
A. M. Ellis
Judith Stone
L. D. Wilson

D. PROGRAM DESIGN CONTROL

In order that the program design section may concentrate on the problems of program and table design, all other responsibilities were transferred elsewhere within the Group (equipment and operational specifications coordination, coding specifications file, typing and distribution).

A study has begun relative to a card-processing system for table design data. Such a system would be used to produce, in terms of table blocks and items set or used within those blocks, information on program, table, item, and value descriptions; drum and core memory locations and allocations for all DCA programs and tables; and required DCA program environments. A system of decks has been initially designed to carry the pertinent table-design data, process this data into a variety of listings, and list the desired weekly publications that are to be produced by the system. The time estimates for card processing of this initial design will be reduced as refinements to the system are accomplished and it is hoped that the system will be producing useful table design data by 1 March 1957.

Sequence parameters were expanded to include all of the subprograms in Package A. These parameters were constructed using the core and drum allocations as originally designed, as the start of assembly testing, in effect, "froze" the actual locations. Since sequence parameters and the communication tag pool are related, a change to one often affects the other. A program is being designed which will check such things as overlap of tables, or programs, in core storage when one or the other is changed.

H. Rising
Mary Ferguson
H. Gochman
H. Newhall
E. Lundberg

*MIT Lincoln Laboratory Quarterly Progress Report, Section VII, C (15 September 1956).

ADMINISTRATION AND SERVICES

Division Head

Everett, R. R.

Associate Division Head

Taylor, N. H.

Assistant Division Heads

Dodd, S. H.
Jacobs, J. F.

Staff

Farr, C. W.
Parkins, T. R.

GROUP 60

Proctor, J. C., Leader

Attridge, W. S., Jr.
Biagiotti, R. J.
Essler, G.
Falcione, A. M.
Ferguson, M. M.
Gray, P. J.
Hazel, F. P.
Heidler, G. R.
Hill, A. P.
Hodgdon, H. W.
Kates, W. A.
Levenson, Judith A.
Mason, C. D.
Mason, Elsie
Miller, R.
Morley, H. B.
Smith, A. R.

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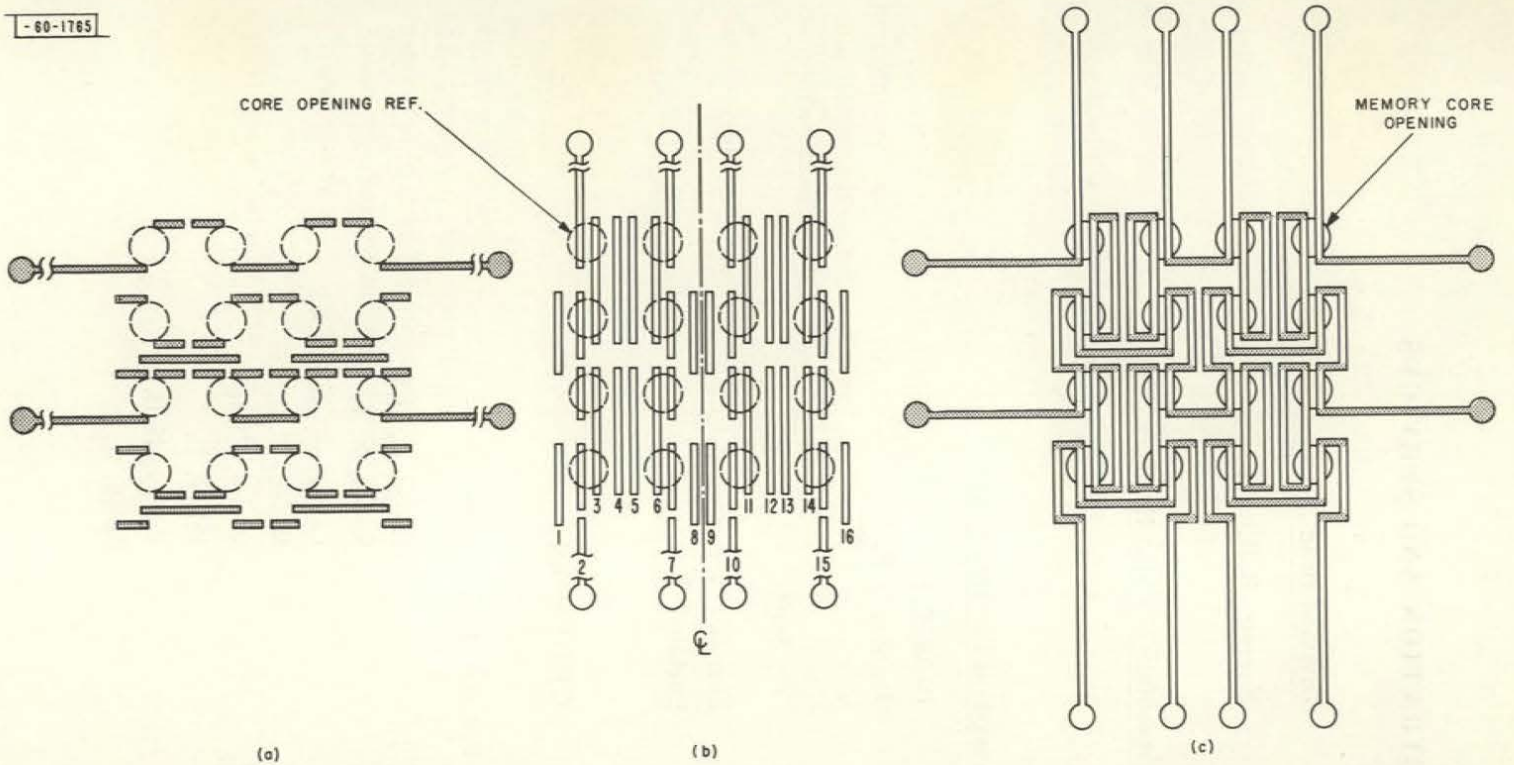

Fig. 60-1. Horizontal (a) and vertical (b) line segments for forming complete printed memory plane pattern for rear mask (c).

Fig. 60-2. Front and rear patterns for a 4 × 4 printed memory plane reproduced actual size.

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VIII. ADMINISTRATION AND SERVICES
GROUP 60

A. SUMMARY

The major effort of Group 60 is of a routine supporting nature. However, the following General Engineering work is considered noteworthy.

A close six-week schedule required to implement the WW I expansion was maintained.

To provide the hardware necessary to incorporate in WW I long-range radar inputs, FST-2 inputs, and 4096 additional registers of core storage, and to modify existing crosstelling equipment, it was necessary to schedule and route various fabrication and finishing operations through 21 different production facilities.

During the same period, a method was developed for economically producing accurate planar masks to actual size for print-wired memory planes.

J. C. Proctor

B. GENERAL ENGINEERING

1. Production Control

Planned expansion of WW I included additional long-range radar input facilities, modification of crosstelling equipment, and 4,096 registers of core storage. General Engineering scheduled and routed the hardware fabrication and finish through 21 separate production facilities within six weeks.

TX-2 production will require a similar production control effort. Delivery of plug-in units was scheduled to begin early in November and continue through mid-March. Twenty-three production facilities will be required for the 2000 plug-in units and their associated drivers and amplifiers.

2. Printed Memory Planes

A method, termed selective masking, has been developed for economically producing, to an accuracy of ±0.001" or better, planar masks for 4 × 4 (16 core) print-wired memory planes. By standard photographic techniques, two positive transparencies are made for each mask – one for the vertical and one for the horizontal. Figs. 60-1(a) and (b) show how the pattern is divided into vertical and horizontal line segments. The two positive transparencies are superimposed in register to print a negative image mask of the wiring pattern. A sample of the rear mask pattern is shown in Fig. 60-1(c). Contact prints from the negative masks show the front and rear wiring patterns for 4 × 4 planes (Fig. 60-2). Selective masking permits actual size wiring patterns without the cost and inaccuracies of photographic reduction.

A. R. Smith
G. Essler
G. R. Heidler

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